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THE CARE OF THE LEAD WORKER *

BY

RONALD E. LANE

From the Nuffield Department of Occupational Health, Victoria University, Manchester

(RECEIVED FOR PUBLICATION, FEBRUARY 22, 1949)

In establishing these lectures Dr. Milroy expressed the desire that they should " promote the advance of medical science along with the interests of . . . social welfare." He pointed out that there was " a vast amount of protracted malaise and suffering, disablement or lessened capacity for industrial work, whose origination will probably be found to be largely due to the neglect of some of those natural laws of healthy existence, with the consideration of which the science of public hygiene professes to deal." I therefore make no apology for the choice of my subject, and this for two reasons; first because the history of industrial lead poisoning in this country over the last eighty years provides an excellent example of preventive medicine, and second because—though lead poisoning is happily now a rare disease, the use of lead is still increasing, and if this is to remain safe the informed help of medical men will be required.

Progress Toward Sound Standards of Safety

In these lectures I have no intention of discussing the voluminous literature on lead poisoning. This has grown rapidly with the years and has recently been surveyed by Cantarow and Trumper (1944), nor do I intend to discuss clinical plumbism, but rather in a brief review of the history of the prevention of this disease in Great Britain I hope to demonstrate our method of dealing with problems of this type, showing its weakness as well as its strength. Then I wish to discuss in the light of experience some of the practical problems involved in the care of the lead worker, in the hope that the doctor faced with this task may be better able to evaluate some of the contradictory advice he may be offered.

Historical Facts and Survey of the Uses of Lead

Lead has been used from ancient times. Its peculiar properties of malleability and resistance to corrosion, together with the chemical and physical properties of many of its compounds, have rendered it of inestimable value in many fields of human activity. Its consumption has steadily risen and at the present time it is scarce throughout the world. It is perhaps not fully realized how widespread is its use; in a survey carried out by the United States Public Health Service in 1940, involving nearly 17,000 factories and a million and a half workers, it was found that rather more than half were handling lead or its compounds. The steady increase in the consumption in this country up to 1939 suggests an expansion in its use here; despite this, the incidence of lead poisoning in Great Britain has fallen steadily throughout the century (fig. 1).

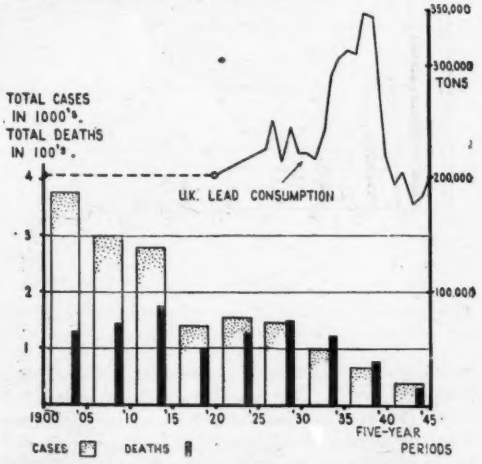

FIG. 1.—Notified cases of lead poisoning, 1900–45.

The toxic effects of lead were known to the ancients. Throughout the last 2,000 years its clinical manifestations have been recognized. At the end of the eighteenth century Percival (1774) published a small work which dealt with " Observations and Experiments on the Power of Lead," and it was over a hundred years ago that Tanquerel des Planches (1839) published his famous treatise giving a detailed and accurate account of lead poisoning, but it was not until the end of the nineteenth century that legislation was introduced to protect the lead

* Being the Milroy Lectures delivered before the Royal College of Physicians in London in May 1947.

worker from the hazards of his occupation. Sigerist (1943) maintains that the history of industrial disease reflects some of the most important chapters in the progress of human civilization and social evolution. This is well illustrated by the history of lead poisoning in the industry of Great Britain, which shows how our industrial society has sought to protect itself from this particular type of social ill. In the evolution of our present methods, workers, employers, legislators, and doctors have played their respective parts. In some cases these have been progressive, in others the reverse.

The efforts of early reformers like Shaftesbury and Fielden had been directed to conditions in the

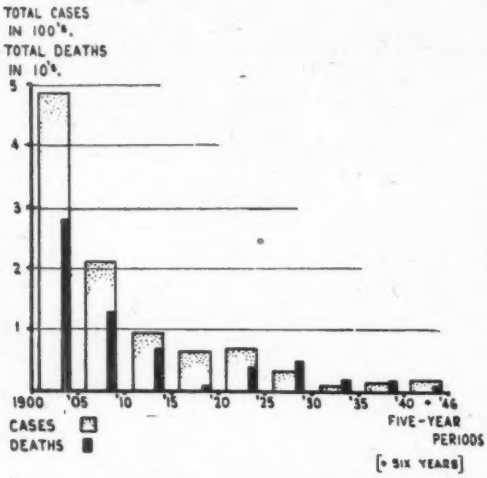

FIG. 2.—Notified cases of lead poisoning in white and red lead trades, 1900–46.

textile mills, the abuse of juvenile labour, and long hours of work. The next period dealt with what Legge (1934) calls " the toll of life and limb resulting from unguarded machinery," and then, finally, at the end of the century the attack on toxic substances began. What those two Manchester physicians Percival and Ferrier had done for the textile industry at the beginning of the century, Legge and Oliver did for the lead trades a hundred years later. The name of Sir Thomas Legge, then His Majesty's Senior Medical Inspector of Factories, will always be associated with the cause of the lead worker. While there was probably an element of scientific curiosity about his approach to this problem, the stronger motive for his unsparing efforts was undoubtedly to be found in his genuine distress and indignation at the sight of large numbers of workers poisoned in the course of their work. The historical side is emphasized because it is important to see this subject, not in isolation, but in relation to the whole subject of occupational disease, and as a part of a bigger picture of industrial medicine. While industrial medicine must never be confined either to toxicology or to a casualty service, it must nevertheless be realized that it was the existence of these obvious ills in our factories and workshops which gave the doctor opportunities to come into industry in the first place, and if in dealing with them he discovered new problems of even greater importance, because of their wider distribution, it is not surprising that they have remained unrecognized by many, as did the old industrial diseases of the past.

Under the Factories Act of 1895 lead poisoning became a notifiable disease ; this was an important landmark because from this time on its incidence was to become widely known. Reports of departmental committees set up over the next few years to consider its incidence in such industries as pottery and coach painting provide interesting side-lights on those industries at that time. Often the claims and suggestions of the workers were, in the light of modern knowledge, correct, but these were frequently met by resistance on the part of small groups of employers. Gradually, however, these objections were overcome, and as the years have passed it has become common practice to introduce regulations and orders where it was shown that a trade or process was dangerous. In drawing up these codes it is always the custom to consult workers and employers in the industry, and to work out with them the best methods for providing safe working conditions. There are at present eleven such codes (nine requiring medical examination) dealing with lead.

White Lead (fig. 2).—An excellent example is provided by the early history of the white lead industry. In the latter part of the nineteenth century the manufacture of lead carbonate was a prolific cause of lead poisoning. Charles Dickens in " All the Year Round " drew attention to it, and in 1882 the Guardians of the Poor of Holborn complained of the cases of lead poisoning which were becoming a charge upon them. There were apparently in the wards of the Union Workhouse at this time no less than fifty-four cases (six were men and forty-eight women). The women were all engaged in the manufacture of white lead. A white lead works in London produced sixty-four cases of lead poisoning in nine months. These were the conditions when the first legislation dealing with this industry was introduced in 1883, and it was not until fifteen years later that regulations prohibiting

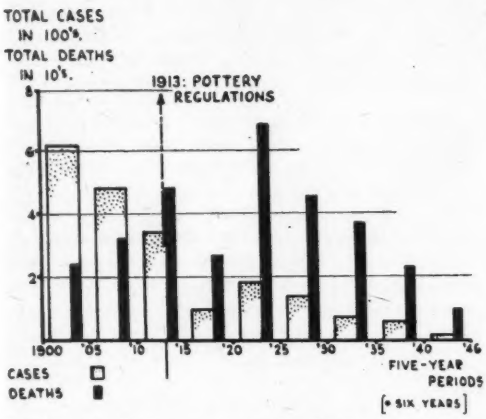

FIG. 3.—Notified cases of lead poisoning in pottery industry, 1900–46.

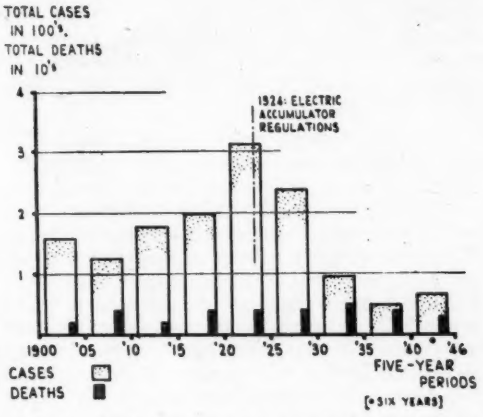

FIG. 4.—Notified cases of lead poisoning in electric accumulator industry, 1900–46.

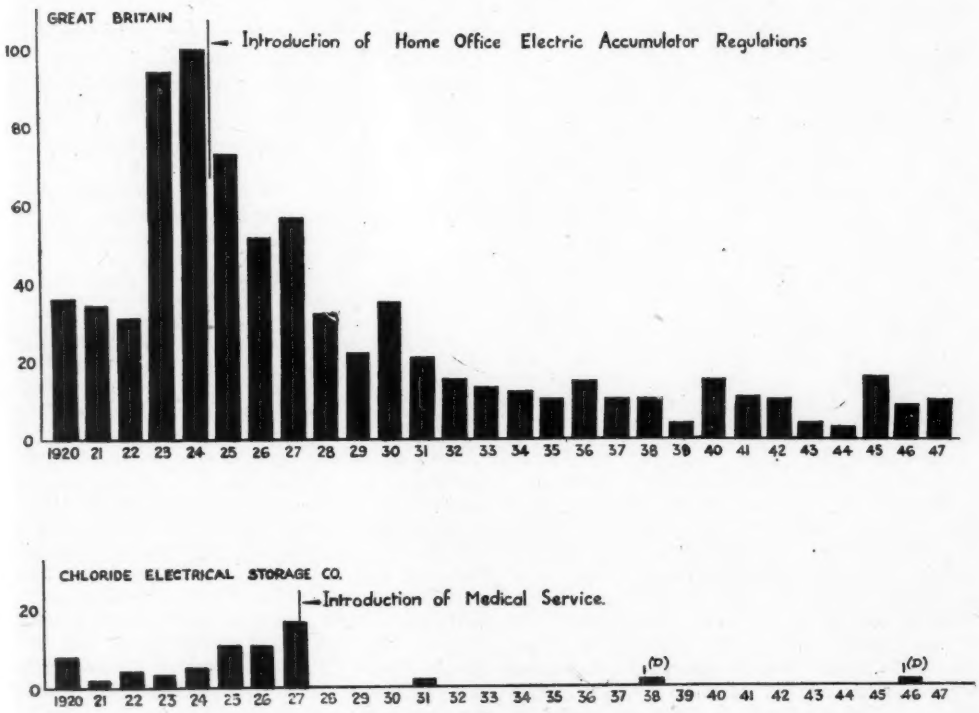

FIG. 5.—Lead poisoning in electric accumulator works.

the employment of women in certain of the more dangerous processes were introduced. There was still such "sanctity of property," and "freedom of enterprise" was given such scope that efforts to improve the lot of the factory worker, even when his work involved him in considerable danger, were met by stubborn opposition.

The Pottery Industry (fig. 3).—A small geographical area of North Staffordshire is almost completely devoted to the manufacture of pottery. There are some 350 different works and some 70,000 workers. At the end of the nineteenth century the incidence of lead poisoning had reached alarming proportions and the pottery industry was declared a dangerous trade, and in 1894 special rules covering it were introduced. By these an employer was required to provide overalls, washing accommodation, cleaning equipment, and eating in the factory was forbidden. Other similar codes of rules were introduced from time to time, but with limited success, until 1913, when the Pottery Regulations took effect. These regulations tackled the problem in two ways. They laid down certain minimum standards for general working conditions and they prescribed the detailed regulation of various processes in which lead risks were encountered. It is probable that these regulations were the most successful that have ever been introduced, though it is difficult to judge because of the increased use about this time of leadless or low-solubility glaze. There is no doubt, however, as to the results. In 1898 there were 457 cases in the year, in 1919 this number had fallen to twenty-one, and the year before the war there were seven cases reported.

Frequently we find that the progressive employer had forestalled the introduction of regulations and had voluntarily established improved conditions, so that the function of legislation was merely to impose on the whole trade those standards and conditions which the more progressive members had shown to be desirable. An example is seen in the electric accumulator industry (fig. 4).

The Electric Accumulator Industry.—The history of the electric accumulator industry is interesting. It was working under a code of rules which were introduced in 1903. In the years immediately following the 1914–18 war the incidence of lead poisoning in this comparatively small industry rose alarmingly, and in 1925 regulations were introduced. These were based on the practices already employed by the most progressive of the battery manufacturers. In other words the most advanced practice was made to apply to the whole industry. This resulted in a drop in the number of cases of poisoning in the industry, but despite these regulations cases in the particular company which served as a model continued to rise as the company grew in size. It was not until three years later, when a medical service was introduced into this particular factory, that cases disappeared: a further voluntary step forward had been taken by the employer (fig. 5).

The Incidence of Lead Poisoning by trade does not correspond to the weight of lead used, but depends upon the form in which it is used. The approximate distribution of our annual lead consumption by trades is shown in fig. 6. It will be seen immediately that the bulk of lead is used in cable manufacture and in sheet and pipe work. There is, however, practically no lead poisoning in these industries,

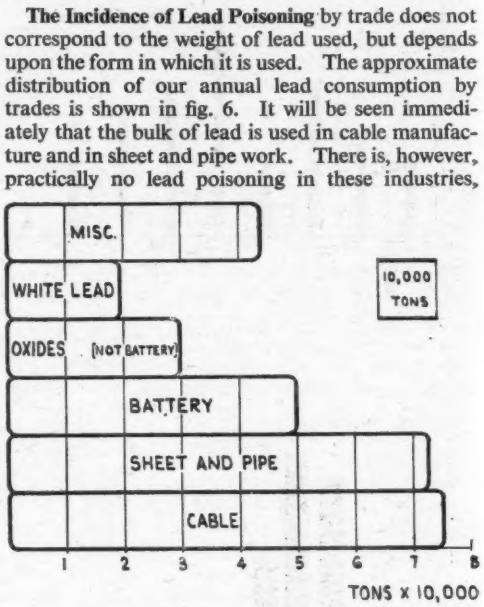

FIG. 6.—Main use of lead in 1945.

where the lead is used in metallic form. The dangerous industries are those in which lead is encountered in dusty form.

New Hazards for Old.—As the years have passed the use of lead in certain industries has dwindled, while new uses in other industries have been found. For instance the use of lead in coach painting has been largely superseded by modern methods, but a new hazard has been added in the manufacture of motor car bodies. In this process a lead-containing alloy is used in considerable quantities in completing the body work. Excess of lead is removed by a rapidly revolving abrasive disc, with the result that fine particles of lead are thrown into the atmosphere. When this process first started in America a large number of cases of lead poisoning resulted, and when it was introduced into this country before the war difficulties were encountered. At present some 28 lb. of 80 per cent. alloy is used for a car body. In the United States they have, by better engineering, been able to reduce the quantity

to approximately 6 lb. While this shows an improvement, this process is likely to remain dangerous so long as open discing is employed. It was interesting recently to see, on one of America's busiest car production lines, hand filing replacing discing on this process, with excellent results from the point of view of hygiene.

Another use of lead has been found in producing anti-knock petrol. This involved the manufacture of lead tetra-ethyl, which is a highly toxic substance. The manufacturers realized the dangers and evolved elaborate methods of protection for those engaged on the process. The fact that it has been possible to manufacture and mix this highly toxic substance, and distribute it throughout the world with comparative safety, is due in part to the work of Kehoe and his associates (1935), and provides an excellent illustration of the type of medical investigation that is necessary, and the planning and administration that are subsequently required, if processes of this type are to be carried on without danger to those employed.

The recent extensive use of lead as an insecticide has, in the U.S.A., introduced new health problems and is throwing an added strain on already restricted supplies. These are but a few of the new uses that are being found for it; as it is superseded in one industry as a result of technical advances, progress in other fields demands its introduction.

Portals of Entry

It early became obvious that if progress were to be made in the control of industrial lead poisoning certain factual knowledge was essential.

The Respiratory Tract.—Since the seventeenth century the respiratory tract had been suspected to be the main portal of entry, but this appears to have been largely ignored in the earliest legislation, which, beyond providing for washing, did very little else. It was not surprising, therefore, that these first regulations met with little success. Goadby reported to the Departmental Committee on the use of lead in the pottery industry (1910) that the respiratory tract was the main portal of entry, and Legge continually preached this and based upon it the regulations covering the lead industries in this country.

The Gastro-intestinal Tract.—Considerable quantities of lead enter the gastro-intestinal tract, but pass through the gut without absorption. It is probable that much of the lead dust that is inhaled is eventually swallowed and appears in the fæces; in fact the estimation of fæcal lead may be used as an indication of the hazard to which a man is subjected, though it does not give any indication of the quantity of lead absorbed. Although lead is not so readily absorbed from the gastro-intestinal tract as from the respiratory tract, absorption by this route does take place and appropriate care is necessary to prevent it, so that eating, chewing, and smoking are prohibited in a lead works under regulations.

The Skin.—Certain organic lead compounds can enter the circulation through the skin. Lead tetra-ethyl is the only one of these likely to be encountered in industry, and its handling in the unmixed state is very carefully controlled. When blended with petrol it is diluted to the extent of some one part in 1,200, and in this form presents no special danger. Recent experience (H.M. Inspector of Factories Report, 1944) would emphasize the danger of cleaning out storage tanks in which ethyl petrol had been stored, unless special precautions are taken. Here absorption is mostly by way of the respiratory tract.

Danger of Dust and Fumes.—Consideration of these facts makes it obvious that it will be in those trades which expose the worker to lead dust or lead fume that poisoning is likely to be found. Cold metallic lead is harmless, but when it is melted fume is given off, though not in appreciable quantities until the temperature reaches 800° C. In addition, oxides form on the surface of melted lead and their removal is likely to give rise to a respirable dust unless great care is exercised. Lead fumes may also be produced in lead burning (welding), in shipbreaking where heavily painted steel plates are cut through with the acetylene torch, and in homogeneous welding and numerous other processes. All these occupations which expose the worker to lead fumes are potentially dangerous and will need special control. Most trouble, however, comes from the dusty trades where lead compounds are encountered or where metallic lead is present in such a fine state of sub-division that it can be breathed.

Lead in Air Estimation

It early became obvious that some objective measure of a hazard was necessary. Engineers and chemists who were working to improve conditions demanded some specification to which to work. As early as 1909 Legge, with the chemical assistance of Duckering, had set a limit of 5 mg. per 10 cu. m. in the air breathed. He pointed out that if contamination were kept below this, cases of serious lead poisoning would rarely occur. By modern standards this figure is far too high but its introduction by Legge shows a definite advance in the

TABLE 1

SHOWING RESULT OF IMPROVING WORKING CONDITIONS

No.	December 1927		December 1929	
	Punctate basophils (per million R.B.C.	Lead in air, 11 det. (mg. per 10 cu. m.)	Punctate basophils (per million R.B.C.)	Lead in air, 12 det. (mg. per 10 cu. m.)
1[1]	13,200 S.M.L.			
2	6,100 S.M.L.		2,400 S.M.	
3	1,500 S.M.			
4	5,700 S.M.L.	5·4	4,000 S.	1·9
5[2]	27,100 S.M.L.	4·7		2·4
6	12,100 S.M.	4·2	1,100 S.	2·8
7	4,500 S.M.L.	3·5	1,200 S.	1·6
8[1]	11,000 S.M.L.	4·4	1,900 S.	1·9
9	4,000 S.M.	4·3		2·0
10[2]	32,300 S.M.L.	8·8		2·5
11[1]	10,500 S.M.L.	5·3		1·4
12	4,300 S.M.	7·1	800 S.	2·8
13	6,100 S.M.	3·6	2,100 S.	1·2
14	6,600 S.M.L.	7·7	6,000 S.	1·7
15	5,500 S.M.L.		1,400 S.M.	1·1
16	7,100 S.M.		2,400 S.	
17	5,000 S.M.L.			
18	6,100 S.M.L.		1,500 S.	
19[2]	44,800 S.M.L.			
20	3,100 S.M.L.			
21			3,800 S.	
22			2,300 S.	
23			600 S.	
24			1,600 S.	
25			2,400 S.	
26			3,500 S.M.	
27			2,100 S.	
28			500 S.	
29			Free	
Av.	10,800 S.M.L.	5·4	2,100 S.	1·9

[1] Case of mild plumbism with debility.
[2] Case of clinical plumbism with colic.
S.M.L. = small, medium, large granules respectively.
det. = determinations.

approach to the problem; it is the first effort to set a definite limit to air contamination.

This figure remained unchallenged for some 25 years, when Russell and others (1933) set a new safety limit of 1·5 mg. per 10 cu. m. Working independently in this country I suggested in 1936 that the maximum permitted contamination of the atmosphere with lead be fixed at 2 mg. per 10 cu. m. (Lane, 1936). The suggestion made by Hamlin and Weber (1947) that a return should be made to the old limit of 5 mg. per 10 cu. m. in the brass foundry industry is untenable, since they admit six cases of poisoning a year under such conditions. In Table 1 are recorded the results of exposure of this magnitude to lead oxide. Drinker (1947) has recently drawn attention to the need for less stringent standards where the more insoluble lead compounds are concerned.

This method of hygienic control has much to be said for it and should be in use wherever there is an appreciable lead hazard. Air sampling may be carried out by one of three methods; the filter, the impinger, or the electrostatic precipitator. Chemical methods of estimation of lead must be selected to suit the particular conditions of the industry, taking into consideration such questions as "interfering substances" and the expected lead contamination of the atmosphere. It is well to have regular routine surveys of this type carried out, and for this purpose fixed sampling spots should be used.

This method is not by any means infallible, it is frequently found that while "lead in air" figures have been satisfactory, evidence of excessive absorption has still been present. This is particularly likely to happen if the worker is engaged on a process where lead in the form of paste or sludge is allowed to dry on the clothing. This is apt to give rise to what might be termed a "personal dust"—imperceptible, but sufficiently real to produce a rise in the lead content of the air the worker actually breathes, though not materially affecting the general atmosphere tested.

Need for Biological Tests of Exposure

While, therefore, "lead in air" determinations have an important place in the control of lead processes, it must be stressed that they provide but an indication. The final test must be the biological one: what is actually happening to the man must be known. This depends on dosage, which, in turn, is determined not only by the concentration of lead in the air, but on two other factors; (1) time, and (2) dust retention.

Length of Time of Exposure.—The length of time a worker is exposed will largely determine his daily dosage. Hours of work are therefore of the greatest importance, and when atmospheric contamination approaches the maximum limit these hours should be just as strictly controlled as the lead in air; otherwise tissue concentration will rise to undesirable levels. It is wise, therefore, to insist on a forty-hour week maximum for all heavily exposed workers (1·5 mg. per 10 cu. m.), whilst in certain processes where control is of necessity less certain only a thirty-six-hour week in contact may be permitted with safety, or perhaps alternative employment by four-weekly periods may be insisted upon. It is surprising that more attention has not been paid to hours of work in the Codes of Regulations.

Dust Retention.—The other controllable factor which will influence dosage in addition to the lead in air concentration and length of exposure is depth

of respiration, influenced for example by the physical effort involved in the work. Hepple (1930) found that with low concentrations such as are found in industry, for shallow breathing, while at rest, some 16 per cent. of the lead which enters is retained, and that on deeper breathing, such as results from gentle exercise, 33 per cent. is retained. In other words, with deeper breathing not only is more lead introduced into the respiratory tract, but twice as much is retained.

Delayed Symptoms.—By careful attention to these details it has apparently been possible to keep large numbers of men quite fit. It has certainly been possible to keep them free from symptoms, but in view of the insidious nature of the action of lead it is of the greatest importance that we should be certain not only that it is producing no toxic episodes, but that it is producing no slow or long-term changes which may shorten life or affect health after middle age. Such a change is more difficult to detect. There is one particular action about which we must be certain: the cardiovascular and renal effects. There has been a tendency in the U.S.A. to think lightly of our reports in this country of "chronic nephritis" as a late effect of lead poisoning (Mayers, 1947). Perhaps the peculiar conditions of much American industry and the greater tendency of workers to move from job to job, makes long term exposure less common there, or renders changes more difficult to detect. There is no doubt that the "tight communities" of Great Britain, particularly as they existed forty years ago, gave much better opportunity for observation of these long-term effects. This problem is of great practical importance.

The Kidneys and Hypertension

The effect of lead upon the kidneys has been widely discussed and has been the subject of considerable controversy. Animal experiments have been carried out on rabbits, guinea-pigs, and cats, and various techniques have been employed. The majority of the investigators report changes of two types, tubular and vascular. Further consideration of these results leads to the view that the tubular changes have resulted from very heavy exposure of an acute type, and the work of Bell and others (1925) on human cases of cancer injected with colloidal lead preparations would confirm this. Under these conditions these workers found marked degenerative changes in the renal tubules. It must be stated at once that this represents the reaction to gross assault by a heavy metal, and is not comparable with conditions involving long-continued exposure to smaller doses; it will not therefore be considered any further.

The vascular lesions reported in animals have been observed by most workers in this field, the most common finding being a thickening of the intima in the smaller renal vessels, and most workers are of opinion that the changes seen in animals are of the type which would proceed to a terminal nephro-sclerosis.

In this country chronic renal changes have been accepted as a sequela of industrial lead poisoning and have ranked for compensation accordingly. The evidence on which this is based was largely clinical, but it was of such weight as to demand attention. Oliver (1914) says, "Of all the internal organs the kidneys are perhaps those in which structural changes are most marked. Because interstitial nephritis or contracted kidney is the most common pathological event in chronic plumbism it has come to be regarded as the typical renal lesion of lead poisoning. It is undoubtedly the lesion of chronic lead poisoning; it is found in persons who have worked in lead for years." Legge and Goadby (1912) discuss the Registrar General's figures for 1900–02, which show a rate from "Bright's Disease" among lead workers of 160 as compared with thirty-five for all males. They regard this as confirmatory evidence "if any were needed" that chronic Bright's Disease is a sequela of lead poisoning.

The lag of some twenty-five years between the fall in the number of deaths from lead poisoning and the introduction of legislation controlling working conditions is clearly seen in fig. 3, and would appear to be evidence in favour of the contention of the older workers.

Many other observers describe vascular changes in the kidneys of lead workers, and Fishberg (1939) states that the renal lesions are arteriosclerotic, though he qualifies this by saying that in a small number of cases there is an arteriolar necrosis similar to that found in malignant hypertension. The work of Nye (1933) in Queensland is important. He records that, of thirty-four individuals who suffered from serious lead poisoning with palsies during their childhood, twenty-four developed renal disease later in life. His observations would suggest that young tissue is particularly susceptible to lead. Most American workers regard the evidence of kidney damage in chronic lead poisoning as far from convincing.

Over the last fifteen years I have seen nine deaths from hypertension, with renal failure, in lead workers who had been exposed in the "bad days" of the industry to very severe lead absorption, estimated at more than 5 mg. per 10 cu. m. (Table 2). These men all showed a similar clinical picture. They had worked steadily for periods varying from

TABLE 2

ANALYSIS OF NINE DEATHS FROM HYPERTENSION WITH RENAL FAILURE IN LEAD WORKERS

Case	Age at death	Years exposure	Process	Family history	
				Father died	Mother died
1	46	22	Hand paster	78	82
2	49	32		76	84 (A)
3	52	24		?	60
4	50	18		82	81
5	51	20		72	69
6	51	32 (started at 17)	Heavy dust and fume exposure	70	75
7	49	30		80	78
8	42	28 (started at 14)		49 (lead p.)	63 (heart dis.)
9	46	21	Hand paster	No records	

A = alive.

within one month to a year of their death due to renal failure. In only one case was it possible to find any typical family history suggesting hypertension, and in this instance the patient's father had also died from "lead poisoning" at the age of 49. The striking feature of these deaths is the age at which they occurred: an average of 48·4 ranging between 42 and 52. It has been impossible to determine the actual number at risk, but it is estimated that these deaths occurred in a group of about 150 men who remained at high risk sufficiently long to come under review. While it is fully realized that this experience has little statistical significance, it is considered worthy of record that there should be a high incidence of this type of clinical case in a comparatively small group of workers.

I am indebted to Dr. Davson for the following histological report.

Examination of the kidneys at necropsy showed no uniform picture. It would appear that the microscopical appearances depended upon the chronicity of the process. In the more slowly developing cases there was a diminution in the number of glomeruli, some of which were completely fibrosed, others showing peri-glomerular fibrosis, while the vessels showed widespread hyaline arterio-sclerosis of the afferent arteriols and intralobular arteries. Larger arteries showed intimal fibrosis. The picture in these cases was indistinguishable from benign hypertension with progressive renal damage. On the other hand some of the more rapidly progressive cases showed a picture very similar to the malignant phase of arteriolar necrosis. In two other cases certain of the glomeruli show an increase in intercapillary hyaline, somewhat resembling that seen in type 2 nephritis. These were the only cases in which the possibility of lead acting directly to produce a glomerular lesion could be postulated, but as some cases of hypertension may also show similar glomerular changes, no definite inference is justifiable.

The age at which death has occurred would suggest that the hypertension was either malignant or secondary in type (Platt, 1948) while the uneven histological changes would point to the condition being secondary. This interpretation would fit in with the findings already referred to in animal experiments in which sclerosis of the smaller renal vessels was observed following prolonged dosage with lead.

It must be stressed that this disproportionate number of deaths occurred in a small group of men who had long been exposed to bad working conditions—probably comparable with those described by the early observers. The problem that confronts us is whether similar changes are likely to be found after the mild degrees of industrial lead exposure of the present day, and it seems that a study of blood pressure and urine in a suitably exposed group will enable an answer to be given.

It was generally believed by the older workers that long-continued exposure leads to hypertension, and that this condition was unusually common in lead workers (Oliver, 1914; Legge and Goadby, 1912; Teleky, 1937; Fishberg, 1939). Some recent American workers are equally certain that there is no such change. Belknap (1936) for instance, concluded that there was no significant difference in the blood pressure of lead and non-lead workers of similar age groups. His findings, however, cannot be accepted as conclusive, since his sample is by no means representative, as exposure did not persist over a sufficiently long period (in only 17 per cent. did it reach between ten and twenty years). Dreesen and others (1941), in their survey of battery workers for the U.S.A. Public Health Service, were unable to discover any significant change in the blood pressure in these workers. Again, however, the same criticism must be levelled, that the majority of these workers had not been exposed to high concentrations of lead for a sufficiently long time.

Opportunity has occurred to observe over a period of twenty years a large number of lead workers, and a group of fifty-six electric accumulator pasters was selected as being particularly suitable, since their work has always been regarded as a hazardous operation and even now, in a model plant, remains one of the major lead risks. In the early period of their employment they were heavily exposed as judged by modern standards. (Lead in air from 2 to 2·5 mg. per 10 cu. m.; punctate basophil counts 4 to 5 thousand per million;

average lead in urine 200 gamma.) The latter half of their exposure has been at a lower level than this, but has still been considerable (lead in air 1·5; punctate basophil 2,500; average lead in urine 150 gamma). These 56 men fall in the 45 to 54

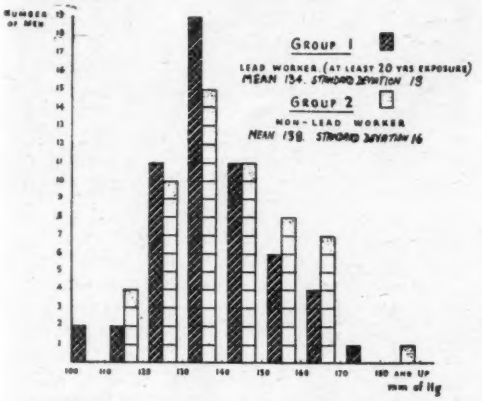

FIG. 7.—Systolic pressures in two groups of fifty-six men from the same locality and social grade, aged 45 to 55 years: lead workers and controls.

years age group. Their mean systolic blood pressure was 134 (standard deviation 13) and the mean diastolic pressure was 88 (standard deviation 10). For comparison a similar number of men of the same age group, from the same district, working in the same factory for the same period, but not in any way connected with lead, was examined. The results were as follows: mean systolic pressure 138 (standard deviation 16), mean diastolic pressure 88 (standard deviation 8) (figs. 7 and 8). As compared with standard pressures for this age group (quoted by Fishberg, 1939, after Symonds) these systolic pressures are slightly higher, as are the diastolic pressures, but this cannot be regarded as due to lead, since the difference is similar for both lead workers and non-lead workers:

Symonds (1923)	
45–49	128·2/84·7
50–54	130·2/85·9

Comparison with Maclaren's figures (1927) shows complete normality:

Maclaren (1927)		
45	134–136	85
50	136–138	86
55	138–140	87

Dreesen and others (1941) report albuminuria as being twice as common in lead workers showing signs of intoxication as in non-lead workers, and they found albuminuria in 39 per cent. of workers who had been heavily exposed (3·0 mg. per 10 cu. m.) for periods in excess of fifteen years.

In my series of 56 pasters a trace of albumin was found in three cases only, while similar findings were present in two of the controls.

The fact that this group of fifty-six lead workers with over twenty years' exposure shows no significant difference either in blood pressure or in urine findings from the control group is highly significant, and can only be due to the fact that their exposure and dosage has not reached a dangerous level. This would account for the disappearance of these so-called cases of chronic Bright's Disease under the improved conditions of modern industry.

It is an important finding, because it does indicate that the standards laid down—chemical and biological—are sound, and that by the use of intelligent medical supervision we know how to eliminate lead poisoning. We can at least write the prescription; the dispensing of that prescription is in the hands of the engineer, the other important member of the industrial health team.

It is thought wise to deal at some length with this question of standards of safety. The slow evolution of safe working conditions in the lead trades of this country has been the result of continued efforts by the Factory Department, a more enlightened attitude on the part of management, Trade Union pressure,

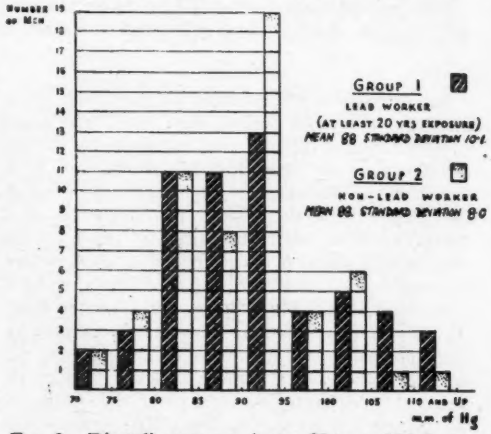

FIG. 8.—Diastolic pressure (mean 88 mm. Hg) in two groups of 56 men (lead workers and controls) from the same locality and social grade (aged 45 to 55 years).

a little scientific investigation, and a lot of action on purely empirical grounds. There has been a change in outlook among the progressive lead trades: they are no longer concerned merely to prevent obvious lead poisoning, but to ensure that there is no damage

to health and no impairment of efficiency on the part of the worker. To ensure this, they have voluntarily adopted certain standards; these standards are safe standards, and their enforcement throughout all the lead trades seems justifiable.

The Doctor and the Patient

In nine lead trades in this country medical supervision is required by law. This provides for frequent (usually monthly) inspection by the doctor. This frequency is itself important, for doctor and patient are brought together in short, but face-to-face, interviews, which provide a good opportunity not only for the doctor to observe slight changes in the workman, but for the establishment of confidence between them which will make the task of supervision easier and more effective. A good relationship of this type is of the utmost importance: everything possible should be done to foster it. Even so, too much reliance must not be placed on the disclosure of subjective symptoms, for many a workman will decide to conceal a symptom that is troubling him because he fears that its disclosure will lead to his removal from his present job, entailing perhaps a drop in wages and separation from his friends and working group. For this reason the doctor will pay particular attention to early objective changes.

The medical supervision may be considered under the heads of selection, supervision and treatment.

Selection

Sex.—Women are excluded by law from work involving the more serious lead risks, and since some doubt has recently been expressed by Baetjer (1946) as to the need for this precaution, it is proposed to discuss it. Regulations prohibiting the employment of women in dangerous lead operations have been introduced at times in the face of opposition from groups of employers and from the women themselves, but on evidence which is considered irrefutable. Oliver (1914) states categorically that "women are more readily affected by lead than men." While one must be influenced by the observations of a shrewd clinician, it must be stated at once that the evidence he brings to support his statement is not convincing. He himself states clearly that women have worked in greater numbers in the more dangerous processes in the white lead industry, and it was on this industry that he was largely basing his opinion. Legge and Goadby (1912) were less dogmatic. They pointed out the difficulty imposed by the inability to secure proper comparison because of different exposure, and Hamilton (1925) has expressed similar doubts. There are, however, interesting statistics to be found in the Report of a Departmental Committee appointed to inquire into the dangers attendant on the use of lead in the manufacture of earthenware and china (1910); these make it possible to compare the incidence of lead poisoning in men and women engaged on the same work—ware cleaners, dippers and dipping assistants (fig. 9). The female incidence rate was shown to be from two to three times that of the male. It must be admitted that even these statistics do not prove the point conclusively, since it may well be held that the labour turnover among the women was higher than among the men, and that in consequence the males on risk represented a "salted" population. It is also possible that the

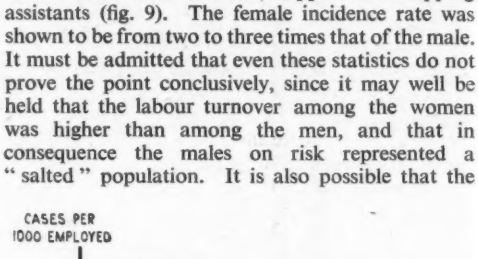

FIG. 9.—Pottery ware cleaners, dippers, and assistant dippers; attack rate per annum, by sex.

actual operations performed by men and women, although done side by side, were more dangerous in the case of women than of men. Be this as it may, the Committee who had all these facts before it accepted this evidence as showing greater susceptibility of women to lead poisoning. This Committee was also impressed by the higher incidence of miscarriage among women engaged in lead work. In some 4,000 cases, including 191 female lead workers, the incidence of miscarriage per hundred mothers was almost three times as great among the lead workers who had worked on lead processes prior to their marriage, and almost four times as great among those who continued on lead work after marriage. This abortifacient action of lead is of course widely recognized and the evidence is unassailable; it must be taken into account in deciding whether or not women are to be allowed to do work involving lead exposure.

Bell and others (1925) place the minimum toxic dose of colloidal lead at 40 mg. in females and 100 mg. in males. While some allowance must be made for weight, this alone cannot account for the difference.

There is one aspect of this problem which is often overlooked. Although women are employed on the lighter types of work, this is not always so, and they are often engaged side by side with men on work which involves, for them, a greater physical effort. This leads inevitably to a raised respiratory exchange with a greater depth of breathing. This has been shown to result in a greater retention of lead dust (Hepple, 1930), so that in addition to any greater susceptibility the actual dosage of lead per pound of body weight is likely to be raised. This may be an additional factor in producing their greater liability to lead poisoning in industry. One therefore cannot agree with Baetjer when she writes that "there appears to be no very convincing evidence that women are more susceptible to lead poisoning than men." The evidence that, given sufficiently large doses, women are more likely to develop lead poisoning than men, must be accepted, while the fact that under these circumstances they are more likely to abort or to lose their children in the first year of life is established beyond doubt, and the wisdom, therefore, of excluding women from the dangerous lead occupations is manifest.

It must be remembered, however, that conditions in the lead industries today are in most cases quite different from those which produced the alarming results reported in the pottery industry in the early years of this century, and where the quantity of lead in the atmosphere can be kept below 1 mg. per 10 cu. m. there is no evidence that women differ from men in the readiness with which they show symptoms of lead poisoning.

During the war opportunity occurred of watching for about three years the effect of lead work on 500 women, of whom one group of 150 were employed on an operation more hazardous than the rest, though still light. The lead content of the atmosphere was low (0·75 mg. per 10 cu. m.), while the lead in urine of men working side by side with these women varied between 0·075 mg. and 0·125 mg. per litre, with a mean of 0·9. These women showed no greater incidence of menstrual abnormalities or of sickness absence than other non-lead workers. But freedom from other effects are not certain. Out of twenty pregnancies it was possible to follow the results of fifteen, and in three cases a stillbirth was reported. These women had all been removed from lead work as soon as pregnancy was disclosed. Though the incidence of miscarriage in this small group is seven times the normal, these numbers are far too small to have statistical significance, since such a finding might have happened by chance in as many as 11 per cent. of cases, but it is recorded in case other observers should have a similar opportunity and be able to add to the numbers.

Consideration of all the evidence, however, would suggest that it is unwise to employ women on operations which expose them to dust or fume in more than minimal quantities, and the soundness of the Factory Regulations in prohibiting women from employment in these operations is fully confirmed.

Age.—Children are regarded as more liable to lead poisoning than adults. It is very difficult to produce conclusive evidence on this point. Legge and Goadby (1912) state that surgeons to lead factories regard them as twice as susceptible as adults, but no figures are given to support this. Where cases of contaminated water supply have resulted in poisoning, it is stated that women and children are the first to succumb. There may, of course, well be other factors to account for this: for instance many men are away from home much more than their families and many, certainly, have a marked antipathy to water as a beverage.

Nye (1933) has recorded the disastrous effects on the kidney in young children who have been heavily exposed to lead in early childhood, and despite the paucity of sound statistical evidence the wisdom of excluding young people from lead exposure cannot be questioned.

Susceptibility.—Pre-employment medical examination is required in most lead trades. This is intended to exclude from this work those whom it is thought might be impaired by it. Those with hypertension, nephritis, peptic ulcer, or epilepsy are better not put to lead work, nor should be the slovenly worker of low intelligence. Where possible it is wise to choose the intelligent, clean, co-operative, well-groomed man of 25 for this work.

That people vary in their susceptibility to lead poisoning is generally recognized. This may be due to fundamental individual differences in metabolism or it may be due to less profound differences such as dietary habits, infections, and malnutrition (Hamilton, 1925; Minot, 1938; Tompsett, 1939). Unfortunately it is nearly always impossible to detect susceptibility before the individual starts work. There is however one pointer which is occasionally of use, the family history. Oliver (1916) reported well established cases of family susceptibility, and Legge and Goadby (1912) support this. They report the case of one family where three sons, two daughters, and the father all suffered from lead poisoning. I have

reported one such case (Lane and Lewey, 1935) and have since seen a second example of this family susceptibility, in which two brothers who did not live together and in whom there was no apparent common factor, beyond the fact that they were brothers, suffered from lead intoxication following very minor degrees of exposure. It would seem that an inborn difference of susceptibility may be encountered.

Supervision

Clinical.—The clinical picture of plumbism is so well known that no attempt will be made to describe it here. Lead has been described as the second great imitator. While this is perhaps true, it must also be remembered that lead workers are not immune from the ills that the rest of mankind is heir to, and that care and sound clinical judgment are necessary in assessing any symptoms which are presented. In passing, it might be well to stress that the earliest symptoms of lead poisoning are often vague: the patient may be moody, irritable and unco-operative, his work may fall off in quantity and quality, and he may be unnaturally tired and yet unable to sleep. Those who are poisoned by lead tetra-ethyl have a symptom complex quite different from that of ordinary plumbism: here sleeplessness is particularly well marked and is accompanied or often preceded by bad and characteristic dreams; in these cases, too, symptoms are often associated with diarrhœa instead of the constipation usually associated with plumbism. The co-operation of intelligent foremen who know the signs of early trouble is often of great value in the detection of early symptoms in their men.

The supervision of lead workers will, however, have failed if the doctor awaits the onset of symptoms by which to judge the safety or otherwise of working conditions. Always he must have in mind that his work is preventive. He is supervising a group; and, while he must be on the look-out for the individual who is specially susceptible, his observation of the group should be such that he will be able to keep working conditions at such a level of perfection that symptoms of lead poisoning do not occur, even among the susceptibles. To achieve this he will rely upon physical signs and upon laboratory aids.

Physical Signs.—The early physical signs of lead poisoning are not numerous, but minor departures from normal are not difficult to observe when the doctor is seeing those in his care each week or each month.

Pallor.—The pallor of lead intoxication is a definite and important sign and calls for action when present. It is an ashen hue and is often associated with a pinched expression about the nose and the sides of the forehead—these latter accompaniments serve in the difficult distinction between the pallor of lead intoxication and the paleness common among those who work in high temperatures, such as coal miners and cotton-room operatives. It has been suggested that this pallor is due to spasm of the capillaries of the skin of the face. Pallor, when present, is an important sign, but it is not always present in those suffering from lead intoxication.

Tremor.—A fine tremor is said to be seen frequently among lead workers and it is often accompanied by fibrillary twitching. This condition may precede paralysis by some months, and is rarely seen in modern industry.

The Lead Line.—The lead line is an extremely useful sign, and in any inspection of lead workers it provides information of value. Known in Great Britain as the Burtonian line, it consists of a deposit of minute bluish grey particles in the substance of the gum and occurs typically about 1 mm. from the tooth. There are various theories as to the mechanism of its production. All are agreed that the appearance is caused by particles of lead sulphide produced by the action of sulphuretted hydrogen on lead, and most observers agree that the sulphuretted hydrogen comes from the decomposition of protein food about the teeth, or from unhealthy gums; for this reason a blue line will not be found in a perfectly clean and healthy mouth. There is not the same unanimity about the route taken by the lead. The older French workers (Renon and Latron, 1900) thought it was secreted in the saliva. Other observers have attributed it to direct absorption by the mucosa of lead entering by the mouth, and there seems little doubt that a blue line can be caused in this way. Goadby (1910) in his report on the pottery industry, reports definite blue lines in workers at the end of one day's work in a dusty process, and in the examination of many hundreds the greater frequency of the blue line on the buccal side of front teeth would lend some weight to this view. The weight of evidence, however, supports Aub and others (1926) in the firm belief that the more usual mechanism is that lead is brought to the gingival margin by the circulation. The appearance of blue lines in cats who received their lead by injection supports this view. This is important, because if this is so the presence of a blue line is a significant finding and does indicate recent circulation of excess lead in the blood stream.

There are various practical points to be made in connexion with the blue line. In examining for it

the use of a lens and a good light are essential ; an illuminated lens is the most convenient instrument to use. The fully developed blue line will rarely be seen nowadays in a good factory, but a few granules about one or two teeth is not uncommon ; these will not be detected without careful examination. A blue line is never seen in the edentulous.

Aub and others (1926) have drawn attention to changes in the gums before the appearance of a blue line—a precursory hyperæmia is certainly not uncommon.

There are various conditions from which a blue line must be distinguished ; the bluish discoloration of pyorrhœa ; this is diffuse and affects the gum up to the margin and should present no great difficulty (though it may accompany a true blue line and is then more difficult to distinguish). Equally common is the appearance presented by sub-gingival tartar which contains carbon, either from urban life or from previous occupation ; on cursory examination it is impossible to distinguish this condition from a true blue line. The suggestion that the corner of a visiting card slipped between the gum and the tooth will assist is valuable in some cases, but not in the more difficult ones where there are only a few granules to be found, and where the blanching of the gum brought about by the insertion of the visiting card obscures the picture. By far the best and safest way is to remove any tartar from the particular tooth or teeth and to re-examine. The appearance of the bismuth line should cause no real difficulty, as its black colour distinguishes it from the true blue line of lead, nor should the brownish deposit of pigment in the gums found in some dark people present any cause for doubt. Another manifestation of lead absorption is described, namely massive staining of the buccal mucosa. This is comparatively rare nowadays and has no different significance from the ordinary blue line.

A blue line is evidence of absorption and circulation of lead in quantities in excess of normal, but its development depends on a second factor, sulphuretted hydrogen, which in turn depends on the presence of natural teeth and on indifferent dental hygiene. Despite this, experience has shown that while a blue line is certainly not to be regarded as a sign of poisoning in the individual, its frequency in a known group is of considerable value in assessing the hazard to which that group is exposed. Table 3 shows, in two groups of workmen, the result of reducing lead absorption, principally by reducing hours of work from 50 to 42 hours per week. The lead content of the air remained unchanged (1·5 mg. per 10 cu. m.).

It is evident from these figures that here the blue line was a sensitive index of the level of lead absorption of the group. It must be stressed once again that this was not a gross blue line, but a very small gingival deposit of lead sulphide which usually clears from the gums in a few weeks if all absorption ceases. The heavy well developed blue line which is easily seen by the naked eye may take as much as twelve months to clear after all lead exposure has ceased ; this type of blue line is now rarely seen in industry, and when present it suggests heavy absorption (Goadby, 1910).

In dealing with the individual workman the blue line tells us no more than is already known, that he is a lead worker and has more circulating lead than normal. It is not a sign in the individual of poisoning. But the incidence of blue lines in a group is a useful finding.

The value to be placed on the blue line is stressed because it is a simple clinical observation which can be made by any doctor who takes the trouble to become familiar with the technique and who provides himself with a simple illuminated lens. He will frequently, however, require to remove tartar before making a decision as to whether a " blue line " is genuine.

TABLE 3

BLUE LINE EFFECT

Group	Year	Number in group	Cases of blue line		Punctate count (average in 1,000's)	No. of men free
			No.	%		
1	1943	66	18	27	1·8	9
	1946	61*	5	8	0·5	4
2	1943	123	43	35	2·5	11
	1946	98†	16	16	0·6	6

* Five men left before 1946 ; none of them had a blue line in 1943.
† Twenty-five men left before 1946 ; four of them had a blue line in 1943.

Laboratory Methods

Useful as a clinical examination is, it cannot be regarded as an entirely satisfactory means of supervision of lead workers. The search for other efficient objective methods has been persistent. The most important of these depend upon the measurement of : (1) lead excretion, (2) lead levels in the circulating blood, and (3) blood changes.

The Medical Inspector of Factories (1945) has recently drawn attention to the use of " figures " in the diagnosis of lead poisoning, and has rightly stressed the importance of their proper use. While

great help is to be obtained from such investigations in the right circumstances, their interpretation demands experience and a knowledge of the physiology and pathology of lead absorption and excretion. Furthermore the accuracy of the figures in question must be beyond doubt. The improvements in modern chemical methods are such that the accurate determination of very small quantities of lead in biological materials is now possible, but the very delicacy of the methods renders it specially important that the greatest care is taken in the collection of the sample, while the laboratory in which the work is done must be suitable. To attempt, for instance, to carry out estimations of this type in the ordinary laboratory of a factory using lead would be almost certain to give trouble. Furthermore, experiment has shown that reliable results are likely to be obtained only when the chemist himself has considerable familiarity with the methods and their difficulties. Odd samples analysed from time to time in a routine hospital laboratory are not likely to be of value. The method used in the determinations discussed below is a standard dithizone method as described by Kench (1940).

Normal Absorption and Excretion of Lead

The daily intake of lead among the general population has been the subject of much research, and the literature has been reviewed by Pope (1932) and by Monier-Williams (1938). The chief source is to be found in the food and in the drinking water, and the average quantity inhaled as dust has been estimated as 0·08 mg. daily (Final Report of the Departmental Committee on Ethyl Petrol, 1930), making an average total normal intake of about 0·50 mg. daily. This figure compares well with that arrived at by Kehoe and others (1935).

This lead is excreted partly in the fæces and partly in the urine. Work by Aub and others (1926) suggests that the quantity excreted by the gut is about 2·5 times greater than that excreted by the kidney, even when lead has been given subcutaneously, but more recent work by Kehoe and others (1943) suggests that renal excretion equals or exceeds that by the alimentary tract. The presence of lead in normal urine has been amply demonstrated by numerous workers, and the importance of considering this normal level before using urinary lead excretion as an indication of lead exposure is apparent.

The normal levels of excretion in urine and fæces are presented in Table 4. When intake is increased the lead content of fæces and urine rises and storage of lead takes place.

In industrial exposure the level of urinary lead does not continue to rise, but reaches a level which is characteristic of the exposure. When such exposure ceases, urinary excretion will gradually drop over the ensuing months.

The value of "lead in urine" determinations in industry is therefore to give a measure of exposure. This method must be applied to the group, and the only satisfactory standard is to apply a range of values with a mean. Kehoe and others (1943) set this mean at 0·1 mg. per litre, with samples not infrequently reaching 0·150 and rarely 0·20. This is a severe standard, and in my experience safety can be achieved at a slightly higher level; a mean of 0·125 with occasional figures of 0·20 and, rarely, figures of 0·23. Large groups of men subjected to this degree of exposure and with no toxic symptoms have been observed for over ten years; though it seems obvious that the lower the figure can be maintained the better.

When absorption exceeds a certain level in the group, cases of plumbism are likely to occur, but not necessarily in those individuals with the higher lead concentrations. There is no exact correlation between the concentration of lead in the urine and clinical plumbism, though on an average those with a high urinary excretion are more likely to succumb.

Not infrequently healthy men have concentrations of lead in their urine of 0·25 mg. per litre or even more, whereas cases showing signs of clinical plumbism may have "lead in urine" concentrations within normal limits. Nevertheless, confirmed

TABLE 4

NORMAL LEAD EXCRETION: FINDINGS OF VARIOUS AUTHORITIES

	Authority	Quantities
Urine	Ethyl Petrol Departmental Committee	0–0·108 mg. per litre
	Tompsett (1939)	0·04–0·05 mg. in 24 hours
	Badham and Taylor (1927)	0·03–0·15 mg. in 24 hours
	Kehoe and others (1935)	0·05–0·1 mg. in 24 hours
		0·02–0·08 mg. per litre
Fæces	Tompsett and Anderson (1935)	0·20–0·4 mg. in 24 hours
	Kehoe and others (1935)	0·02–0·39 mg. in 24 hours

repeated high lead concentrations in urine (0·25 mg. per litre) should call for action in the individual case.

Sampling.—While a twenty-four-hour sample may be desirable, it is impracticable as a general routine in industry, and as a result considerable investigation of the validity of spot sampling has been carried out in America by Levine and Fahy (1945). These workers have shown a high correlation between specific gravity and lead concentration in over 1,150 samples. They recommend that spot sampling be expressed as milligrammes per litre adjusted to a specific gravity of 1024 ; it is usually found in this country that results using their correction tend to be high. There is, however, every justification for using this spot sampling method, though more work upon it in Great Britain is desirable. The actual collecting of samples requires care and a room specially set aside for the purpose, but elaborate bathing as required by Kehoe has not been found necessary in practice.

Estimation of lead in fæces is not a reliable measure of absorption and is not the type of investigation which lends itself to use in industry. Much of the lead in the fæces of a lead worker has never been absorbed, but has passed through the gut without affecting the systemic lead level. Where carried out on a group of men, however, such estimation will give an indication of the exposure to which that group is subjected.

Lead in Blood.—The estimation of lead in blood has been carried out in recent years on a wide scale. The same mistake has been made in interpreting these results as has been made with other laboratory investigation : too much has been claimed for the method, and workers have attempted to establish critical values above which they claim poisoning occurs, and below which safety may be presumed. Wide experience shows that there is no justification for such claims (Sawyer and others, 1939). Personal observations have disclosed healthy lead workers showing values as high as 0·16 mg. per 100 ml., while a case of plumbism showed persistent values within the normal range (0·08 mg. per 100 ml.). That the blood lead values of groups of lead workers are greater than normal has been shown by Dreesen (1941), but changes in lead absorption are not so quickly reflected in these figures as they are in the "lead in urine" figures (Kehoe, 1935). Routine venupunctures among factory workers are not likely to be regarded with favour, and since other more effective methods for control are available "lead in blood" estimations are not regarded as suitable for routine use in industry.

Blood Changes.—The changes in the blood produced by lead are definite, but are not entirely specific. Anæmia is found after heavy exposure and is hypochromic in type. The number of red cells falls, and this is accompanied by a corresponding or slightly greater fall in the hæmoglobin. The decrease in the number of red cells is claimed by Aub and others (1926) to be due to their more easy destruction as a result of the physical changes which take place in the red cell envelope as a result of the presence of lead. The anæmia differs from ordinary hæmolytic anæmia (Rimington, 1938) and is associated with the appearance of coproporphyrin III in the urine. Work by Manchester investigators, however (Kench, Gillam, and Lane, 1942), showed the diminution of hæmoglobin in lead intoxication to result from restricted formation of protoporphyrin rather than from its non-utilization, as had been suggested by Rimington. More recently McFadzean and Davis (1949) had advanced an hypothesis reconciling the theories of faulty hæmoglobin synthesis and hæmolysis.

TABLE 5

PUNCTATE BASOPHIL DANGER LEVELS : FINDINGS OF VARIOUS AUTHORITIES

Authors	Per million
Schmidt (1919)	100
Lehmann (1919)	200
Trautmann (1924)	300
Naegeli (1919)	500
Sellers (1925)	1,000
Belknap (1940)	1,000
Johnson (1937)	2,000
Lane (1931)	3,000

Estimations of hæmoglobin are of considerable value in the supervision of lead workers ; though it is unusual nowadays to find marked anæmia in a lead worker, a persistent hæmoglobin below 85 per cent. in a man should call for investigation.

Changes have been reported in the white cell ratio (Ferguson and Ferguson, 1934 ; Shiels, 1936), but these are not sufficiently constant to be of practical value.

Punctate Basophilia.—The most important change for the purpose of control is that of punctate basophilia. This has been the subject of numerous investigations by a variety of workers. Their results are so contradictory that the literature of the subject is in a state of chaos (Table 5). Most of the disagreement results from workers asking too much of this method and from their attributing to it an undeserved specificity and accuracy. It must be understood at the outset that vastly different results will be obtained if different methods are used to estimate the degree of punctate basophilia, for

example, different staining methods and different methods of microscopy.

Furthermore, different results will be found among different types of lead workers, according to the nature of their exposure. The following is a brief summary of the uses and abuses of this method of control and its practical value to the clinician.

Punctate basophilia appears in a number of conditions, notably pernicious anæmia, the leukæmias, and cachexia following neoplasm. In none

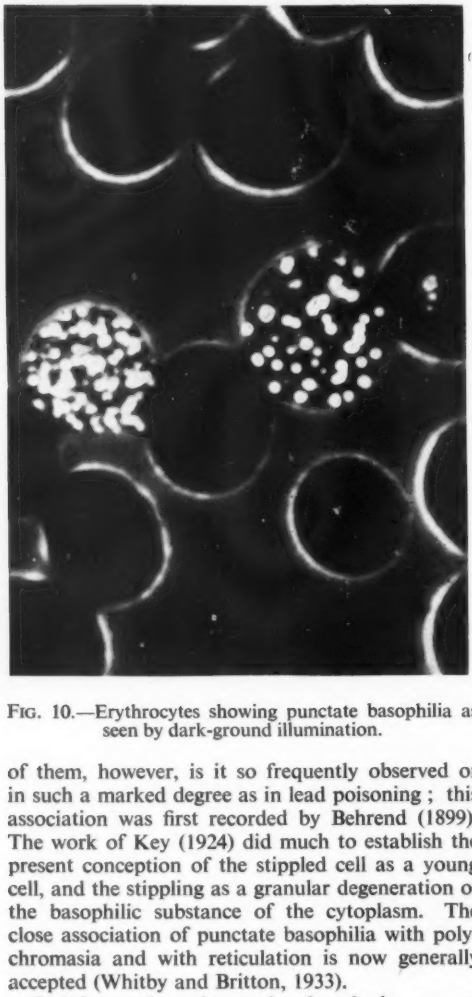

FIG. 10.—Erythrocytes showing punctate basophilia as seen by dark-ground illumination.

of them, however, is it so frequently observed or in such a marked degree as in lead poisoning; this association was first recorded by Behrend (1899). The work of Key (1924) did much to establish the present conception of the stippled cell as a young cell, and the stippling as a granular degeneration of the basophilic substance of the cytoplasm. The close association of punctate basophilia with polychromasia and with reticulation is now generally accepted (Whitby and Britton, 1933).

Certain workers have abandoned the use of punctate basophilia in the supervision of lead workers, and have fallen back on reticulocyte counts (Fleckel and Tschernow, 1930), while one of the most widely used methods, the basophilic aggregation test (McCord and others, 1924), depends on the vital staining of hæmolysed red cells. While these methods are obviously open to objection and are not as specific as punctate basophil counts, they have their uses and possess the advantage that staining methods are laid down and must be carried out, and the resulting microscopical examination is not difficult; so that the variation in the results of different workers is less extreme.

There is little doubt, however, that stippled cell counts are more specific and have definite value, provided always they are carried out in a uniform manner and the results are interpreted with care and reserve.

Method.—A thin film is prepared on a suitably thin glass slide. Fixation is by methyl alcohol followed by staining with an alkaline methylene blue (methylene blue 2 parts, sodium bicarbonate 12 parts, distilled water 400 parts). Washing with tap water is continued until the film has a sea-green colour.

Much trouble has arisen because the fine stippling demonstrated by this method of staining is often difficult to see when using transmitted light, and after short spells the work becomes tedious and the fatigue it induces is likely to lead to many stippled cells being missed. For this reason dark-ground illumination should be used for this work. When employing this method the red cells are seen as circles of light and the stippling appears as golden dots within the circle (fig. 10). Using a 1/12 oil immersion objective, a hundred fields are counted. Ten contiguous fields are scrutinized in 10 different parts of the slide. The size of the granules is noted. An estimate of the number of red cells examined is made by means of an Ehrlich stop, and the number of punctate cells per million erythrocytes is calculated.

This method achieves the ease of counting of the basophilic aggregation test, while retaining the somewhat greater specificity of the stippled count. Counts are considerably higher than when transmitted light is used (approximately twice as great; fig. 11).

Use of Results.—In 1931 I (Lane, 1931) showed that minor degrees of punctate basophilia were to be found in normal individuals, and though later work and a larger series of cases would lead me now to suggest that the incidence of punctate basophilia in the normal population is less than was reported at that time, there can be no doubt that this exists. Punctate basophilia varying between one and three thousand per million has been observed in 8 per cent. of normal individuals when films have been examined by this technique. Kehoe (1935) has

reported counts of over 1,000 per million in 6 per cent. of a group of over 700 normal people. To place great reliance, therefore, on single punctate counts is unsound.

In order that punctate counts may be of value in supervising the lead worker they must be repeated

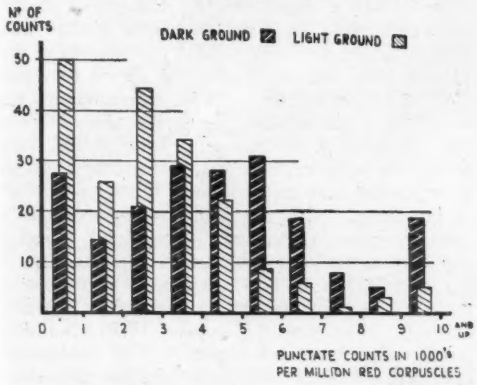

FIG. 11.—Punctate counting, dark- *v.* light-ground methods : two hundred samples.

at frequent intervals, and departures from the normal and general trends must be noted. It has been reported previously (Lane, 1931) that greater significance should be placed on the presence of large granules, and a sharp rise in the count accompanied by the appearance of coarse stippling usually indicates recent increased absorption. Occasionally, where lead absorption has persisted at a fairly high level, the punctate count may drop to a low or normal level despite the continued absorption of lead in undesirable quantities. This change is usually accompanied by a drop in the hæmoglobin level. For this reason a routine hæmoglobin estimation should be made at the same time as the blood is taken for the punctate count. The Haldane method of determination has been found satisfactory in practice.

Punctate basophilia (1–5,000) estimated by the method described above, is likely to be present in minor degrees of lead absorption and in the complete absence of signs or symptoms of poisoning, and appears to be consistent with good health. A number of workers with these small counts have been kept under observation for twenty years, and no departure from normal has been detected (figs. 7 and 8). This supports the finding of Belknap (1940).

The Group.—While a normal unexposed group may show minor degrees of punctate basophilia, this is confined to less than 10 per cent., the majority of the group being free. Lead exposure of significant degree manifests itself by the appearance of punctate basophilia of varying degrees in most members of the group ; most counts show a rise and the mean is raised. The extent of the basophilia and the actual counts will depend on the degree and nature of the lead exposure. It is sometimes suggested, for instance, that exposure to lead fume does not give rise to punctate basophilia ; this is by no means always true. Extensive punctate basophilia in a group of men exposed to nothing but lead fume has been observed on several occasions. Often, however, this type of work does not involve the same degree of dosage with lead as does dusty lead work, and it is probably for this reason that the changes are often less marked (fig. 12).

In those exposed to lead tetra-ethyl punctate basophil count have not the value they have with other lead compounds.

In summary it may be stated that this method provides an easily performed objective measure of absorption for the group, and may single out the individual who is absorbing larger doses of lead than his fellows. This is the value of this particular investigation ; too much must not be asked of it,

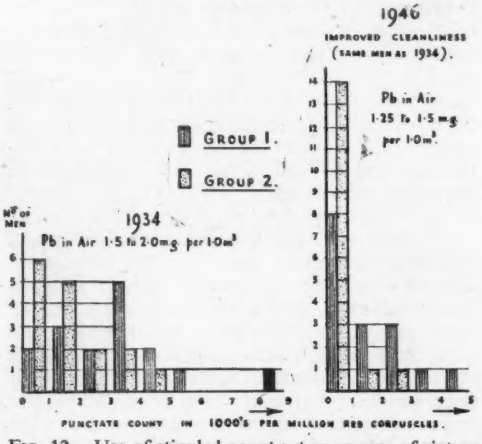
1946
IMPROVED CLEANLINESS (SAME MEN AS 1934).
Pb in Air 1·25 to 1·5 m.g per 1·0m³.
GROUP 1.
GROUP 2.
Nº of Men
1934
Pb in Air 1·5 to 2·0m.g per 1·0m³
PUNCTATE COUNT IN 1000's PER MILLION RED CORPUSCLES.

FIG. 12.—Use of stippled count : two groups of sixteen men on different processes in the same shop.

but it should have a place in any routine control of groups of workers exposed to inorganic lead compounds.

In making a diagnosis of lead poisoning, the finding of punctate basophilia is of value. It is almost invariably present if the patient is seen within a short time of lead exposure. Cases of

lead poisoning have very rarely been seen without marked punctate basophilia, but (excepting cases of tetra-ethyl lead poisoning) these have always been associated with a low hæmoglobin (60 per cent.), and it would seem that here the absence of stippled cells is the result of a severe depression of the bone marrow, resulting in the production of a small number of young red cells. On the other hand a high punctate count may be encountered without any lead poisoning, and occasionally even in a person engaged on work involving a comparatively low lead hazard.

Siderocyte Count.—Case (1945) has studied the effect of lead absorption on the siderocytes of the blood. These erythrocytes contain fragments of non-hæmatin iron which is stainable by appropriate methods, and in his view they are of value in estimating lead absorption. Further investigation of this method of routine control of lead workers is awaited.

The estimation of lead in urine and of punctate basophilia are the laboratory methods of choice in the supervision of the lead worker. Each has a wide range of values, and moderately high figures in some individuals are consistent with continued good health. The inexperienced clinician must therefore resist the temptation to make a diagnosis of plumbism merely on the results of these tests; such a diagnosis can only be made on a careful consideration of the whole history and clinical picture, together with the help these tests give. On the other hand, when applied to the group, a small general shift towards the higher values is of significance and will call for detailed investigation of the conditions of work.

Treatment.—Should a worker show evidence of abnormal absorption (pallor, vague symptoms, drop in hæmoglobin, continued shift in punctate count) he must receive treatment. This merely means stopping lead absorption by suspending him from lead work. Such suspension should not involve financial hardship, and should last for about three months. Any question of return to the old work must receive careful consideration. If it has been possible to modify the operation or conditions of work—including hours—which were responsible for the trouble, the man may be allowed to return. If no such modification is possible he should be considered unsuitable for that particular hazard.

Workmen should not be allowed to go back to a heavy hazard immediately on their return to work after a heavy infection; there is ample evidence that infection is likely to precipitate lead mobilization.

The treatment of acute toxic episodes is sufficiently well known to require no comment.

Prophylaxis.—In the past emphasis has been laid on regular saline cathartics, on vitamins, and on citrates as routine treatment for the lead worker. I should like to express strong disapproval of any such measures. There is one way to prevent lead poisoning and one way only, and that is to make the process safe, and experience has shown that this can be done in the most unpromising trades. Anything which is likely to divert attention from this objective is unwelcome. Furthermore, there is no convincing evidence that these other methods of treatment have any real value in the prevention of poisoning. Milk has long been regarded as a useful preventive measure; Legge and Goadby (1912) thought it acted by reducing the acidity of the stomach. Aub (1926) disagreed with this view, but supported its use on account of its calcium content. More recently Tompsett (1939) has added further experimental evidence to the contention that milk interferes with the absorption of lead in the gastro-intestinal tract.

While most lead is probably absorbed by the respiratory tract, there is little doubt that a certain amount may gain entrace to the body by way of the gastro-intestinal tract. In dusty lead trades, therefore, where lead dust may adhere to the upper respiratory tract and finally find its way to the gut, there may be some scientific basis for giving milk before work; but most of these trades nowadays are capable of adequate engineering control, and this must be regarded as the method of choice. When complete control is not possible, milk may be given. It must be emphasized that there is no need to give milk to the majority of lead workers. This is important now milk is short, and claims for it should be resisted as being against the best interests of the community. There is no doubt that much milk is being diverted from more useful purposes to lead workers exposed to a small hazard who have no real need for it. Conditions are better than in the old days, wages are good, and rationing ensures adequate supplies of essential foods. These are important factors in the care of the lead worker, and extra milk is no longer justified for the majority.

The importance of education of the worker himself must be stressed. He must understand fully the dangers of his work. No attempt must be made to hide it or to minimize it, but he must at the same time be shown his own responsibilities in any safety programme. This needs patience and hard work on the part of the doctor. He must inspire employers and workers alike with enthusiasm for safe working conditions. The employer can,

and must, do a great deal, but final and complete success will be impossible without the co-operation of the workman. This co-operation is forthcoming if the approach is the right one: the responsibility for procuring it lies with the doctor.

Conclusion

In these lectures controversial subjects have been dealt with, and an attempt has been made to show how the supervision of the lead worker may be carried out. That these methods can be successful is illustrated in fig. 5, which shows the incidence of lead poisoning over the last twenty-five years in a large electric accumulator factory in which these measures have been adopted.

I wish to acknowledge the help and encouragement accorded to me over some twenty years by the Directors and Employees of the Chloride Electrical Storage Company Limited. I also wish to acknowledge the help of Mr. H. Varley for lead-in-urine determinations, and of Mr. R. Gray for preparing diagrams.

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AN OUTBREAK OF CASES OF RAYNAUD'S PHENOMENON OF OCCUPATIONAL ORIGIN *

BY

JOHN N. AGATE

From the Department for Research in Industrial Medicine (Medical Research Council), The London Hospital

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INTRODUCTION

Vascular disturbances resulting from the handling of mechanical devices have been recognized since 1911, when Loriga described a case which followed the use of a pneumatic tool. Then Alice Hamilton and others (1918) described, in a long monograph, an outbreak amongst the stonecutters of Louisiana who also used such tools. Pneumatic hammers and chisels have been blamed for most of the cases up to 1945, though Middleton (1930) observed Raynaud's phenomenon in men exposed to intense vibration while working at "pounding-up" machines in the boot and shoe industry. The literature up to 1945 has been summarized in the papers of Hunter, McLaughlin, and Perry (1945), and Agate and Druett (1946, 1947). Up to that time it had been recognized that the harmful processes were those which subjected the workers' hands to repeated hammer blows, and there was much debate as to which were the most harmful tool speeds. No other mechanical tools had yet been found harmful.

In January, 1945, a Trades Union representative in a large Manchester engineering works sought advice about an outbreak of cases of intermittent blanching of the fingers which had already earned the unfortunate name of "dead hand." There could be no doubt from the description that these cases were examples of Raynaud's phenomenon. But the men and women concerned were working neither with pneumatic tools nor pounding-up machines. A start was, therefore, made with clinical and experimental investigations in the hope of finding out the natural history and the ætiology of this outbreak of disease. The experimental work, dealing with the nature of the vibration set up by these tools in comparison with other vibratory tools, has been published previously in this journal (Agate and Druett, 1947). At the same time Telford and others became interested in the problem at this factory, and in 1945 they published a report on the first thirty-four cases they saw. Meanwhile the present investigation continued. It was designed to include a greater number—as many of the workers at risk as possible—and to follow them up over a period. Most of Telford's thirty-four individuals volunteered for a second and independent examination, and will be considered here with the rest.

While this work was going on, the writer, with Druett and Tombleson (1946), also investigated a small outbreak of Raynaud's phenomenon in a group of thirty-seven grinders of small metal castings. Thirty-two were found to be affected. These grinders were all working at large belt-driven wheels mounted in fixed bearings; they pressed small castings against these wheels, and intense vibration was set up. This small outbreak provided confirmation of the view that the chief cause of the disorder is vibration, whether this be set up by hammer-like blows, by rotary hand tools, or by friction at a grinding surface. Gurdjian and Walker (1945) had already described the cases of six women who contracted the same disorder while using small pneumatic hammers for constructional work on aircraft; but they were affected in the hand which held the object to be riveted, not the hand which held the hammer.

Definition

It is now recognized that Maurice Raynaud included amongst the cases he described in his thesis of 1862 examples of several different diseases in which the same manifestations had appeared. At the present time it is usually accepted that the term "Raynaud's disease" shall be used only for a distinct but rare symmetrical vascular disorder of unknown ætiology, which is found mostly in

* This material formed part of a thesis accepted for the M.D. degree of the University of Cambridge.

FIG. 1.—A rotary scurfing tool, similar to that used in the factory.

FIG. 2.—The operator polishing a metal casting with the rotary tool. The grip he uses is the usual one for a right-handed man.

FIG. 3.—Tool heads. (A) emery-dressed felt buff, 3 inches in diameter; (B) silicon-carbide stone, 1½ inches in diameter; (C) large-toothed cutter, and (D) small-toothed cutter, each three-quarters actual size.

young women; similarly, that "Raynaud's phenomenon" shall apply to a symptom or sign, namely, intermittent pallor or cyanosis of the extremities. Hutchinson (1901) advocated the use of the latter term and suggested it should be qualified whenever the ætiology was known. The colour changes of "Raynaud's phenomenon" do occur in cases of "Raynaud's disease" itself, but are also to be seen in such conditions as hereditary cold fingers, certain cases of cervical rib, and "pneumatic hammer disease," amongst others (Hunt, 1936).

The clinical definition of Raynaud's phenomenon given by Hunt will be used here, in spite of the opinion of Allen and others (1946) that it is too narrow for all purposes. Hunt defined Raynaud's phenomenon as:

> "Intermittent pallor or cyanosis of the extremities precipitated by exposure to cold, without clinical evidence of blockage of the large peripheral vessels and with nutritional lesions, if present at all, limited to the skin."

Nomenclature

The following synonyms are to be found in the accounts already published: "dead hand" (Telford and others, 1945; Biden-Steele and King, 1947); "dead fingers"; "white fingers" (Hamilton and others, 1918); "pneumatic hammer disease" (Mills, 1942); "pseudo-Raynaud's disease" (Brocklehurst, 1945); "traumatic vasospastic disease of the hand" (Gurdjian and Walker, 1945). The first three of these are graphic, but are wanting in accuracy: they may have unfortunate mental associations for the sufferers, and their use cannot be defended. The term "pseudo-Raynaud's disease" seems to add nothing to an understanding of the disease and can have no more claim to be used than the name "Raynaud's disease" itself, which has been excluded by definition. Biden-Steele and King (1947) appeal for the abandonment of both "Raynaud's disease" and "Raynaud's phenomenon" on the ground that legal confusion may be caused; but these authors themselves confuse the meanings of the two terms, and have only suggested "dead hand" as an alternative. "Traumatic vasospastic disease" defines the probable ætiology and disorder of function, but has been used by only one author. The name "pneumatic hammer disease," at one time specific, must be considered outmoded in the light of recent experiences.

"Raynaud's phenomenon" is a widely accepted descriptive term, and it is suggested that all vascular disorders of the type under review might best be included within the single diagnosis of "Raynaud's phenomenon of occupational origin," at least until the factors in their causation are all understood. In nearly every case vibration will be found to be the principal factor.

The Present Outbreak

The 1939–45 war had brought fresh kinds of employment to the locality. The engineering works in which the outbreak occurred was a large new one built for war purposes: it absorbed workers from the less essential industries in the district. Therefore many people in the affected departments had

found themselves in an engineering trade for the first time in their lives, and many were already middle-aged. Most of them expected to return to their old peace-time jobs in due course. In the meantime their work consisted of " scurfing " or " polishing " metal castings with rotary hand tools, in the use of which they had had to be specially trained. The working conditions and wages for this job were good. The factory was light, airy, and always sufficiently warm. Excellent medical and welfare departments were maintained, and there were two full-time medical officers. The latter, when consulted about the vascular disturbance, had advised a change of job for those affected and warned the management accordingly. Nevertheless the workpeople had considerable misgivings as to their future working capacity and the permanent effects which this disease might have on their fingers. With the war coming to a close, they also feared they would be declared redundant. Therefore, because of their misgivings, these workers had themselves asked for an investigation to be done, and their willingness to come forward made it possible for nearly all these at risk to be interviewed and examined—a rare enough happening in industrial medical investigations. The management, anxious to determine the extent of the outbreak and to discover preventive measures, were willing for a detailed investigation to take place on the premises. Their laboratory staff had begun experiments to try to reduce tool vibration, but without notable success.

The Tool in Use

More than three hundred men and women in two separate shops were engaged in polishing and grinding castings made either of steel or a " duralumin " type of alloy. The process is also known as " dressing " or " scurfing." For the purpose they used a portable rotating tool which could be adapted to various types of work (fig. 1). It consisted of an electric motor of ½ or 1 horse power suspended from an overhead girder or placed close at hand on the bench : to this was attached a flexible cable, about five feet in length, made up of a central rotating core of thick wire enclosed in a flexible spiral steel covering which was attached to the motor casing. The torque of the motor was transmitted through a system of pulleys by which three different speeds were made possible, that is, approximately 1,220 revolutions per minute (r.p.m.), 2,960 r.p.m., and 7,700 r.p.m. In general, the heavier the work, the lower the speed that was used. At the other end of the cable was a tubular steel hand-piece of about 1½ inches diameter. Its outer casing was attached to the spiral outer covering of the cable and was of convenient size to hold in the hands. Within it a central spindle connected to the core of the cable was free to rotate on three, or sometimes four, sets of ball bearings. The spindle carried a chuck into which various cutting and polishing tools or " heads " could be fixed at will.

Such a tool is ideally suited to polishing the various surfaces of a complex casting, and much of the work could not have been done in any other way. The operatives stood at a bench all through a shift, with the motor of the tool suspended above and behind them. A right-handed man would have it at his right shoulder, the cable passing under his right axilla without touching it, and across his forearm from medial to lateral side ; the proximal end of the handpiece rested in the palm of the supinated right hand. This hand, gripping firmly, steadied the tool and the cable, but the real work and the guiding of the tool would be done by the left hand grasping the distal end of the handpiece with a firm grip just over the chuck, so that the dorsum of the hand was uppermost with the forearm in a pronated position (fig. 2). By this means a strong downwards pressure could be exerted and a side-to-side sweeping action used. Occasionally the cable was passed over the shoulder and an " overhand " grip was used with both hands, though the left would still be nearest the head of the tool. The grip in the case of a left-handed man was usually reversed, with the right hand in front nearest to the head.

In the smaller shop steel crankshafts were being polished. This process was also known as " glazing." For the preliminary rough work 1¼-inch silicon carbide stones on ¼-inch spindles were mounted in the chuck, but for the finer polishing felt " buffs," three inches in diameter, coated with glue and abrasive powder were preferred. Only quite a light stroke was needed to burnish the metal, and only the higher speeds were used. It was generally considered that little vibration was set up in these conditions.

The larger department was for the scurfing of duralumin engine castings. Certain broad surfaces were polished by a variety of emery-dressed buffs, mops, abrasive paper discs, and circular wire brushes, but much the greater part of the work consisted in cutting off surplus metal by means of rotary toothed cutters (fig. 3). Duralumin is of great strength, but it is not very hard, and at slow speeds with suitable cutters a ¼-inch thickness of redundant metal can easily be removed by this rotary tool. Cutters vary from ¼ to 1 inch in diameter and usually have coarse teeth cut in a spiral. An intense vibration is always set up, and a powerful, sustained grip is needed. It is all that a novice can do to hold the tool in position to do the cutting.

The heaviest scurfing work in this factory was usually given to men, but this was not an invariable rule. Sometimes the shape of the casting was such that a number of sizes of cutters had to be used in succession, so that one operator would use a variety of heads in the course of a day. This fact made assessment of the relative importance of each in the production of symptoms a very difficult matter. But at one critical stage of the war an increased output was called for, and a production line was set up. Each worker on this line then did a limited piece of the work and pushed the casting along on rollers to his neighbour without himself having to change cutters. Some of the men were, therefore, obliged to use the larger cutters continuously ; this made comparisons between the " heads " somewhat easier for the clinician to draw, but was probably not in the individual's best interest, because the largest cutters seemed to produce the severest vibration, as will be shown later. The general increase in tempo of the work at this time was blamed by a number of workers as being the immediate cause of their symptoms : certainly it should be considered an aggravating factor in the ætiology.

It is of importance to note that the handpiece of the tool was warm except when work first began in the morning or after a break ; also that the interchangeable cutting and polishing heads were mounted on slender spindles, some of which were several inches long. It was possible for even the shortest of them to be knocked out of alignment. The workers were not trained mechanics and, therefore, would not instinctively correct the alignment ; indeed, by so doing they would feel that they were losing precious time.

THE NATURE AND INCIDENCE OF THE DISORDER : INITIAL FINDINGS

In March, 1945, as many as possible of those who were using the rotating polishing tool, or who had recently given up using it, were interviewed. It was not possible to include any who had already left the firm. A total of 293 workers were seen, of whom forty-seven were women. According to the records made available by the factory personnel department, some thirty to thirty-five other people were also employed in this way, but they had to be missed on account of sickness, leave of absence, or changes of shift. It so happened that most of these were men who usually worked on the largest castings of all : they belonged to the group in which the incidence of vascular disturbances proved to be highest. If, therefore, these thirty or thirty-five individuals could have been interviewed it is likely that the incidence of Raynaud's phenomenon would have been even higher than it is shown to be by the figures which are available.

Each subject was asked to give a full occupational history from the time of leaving school, so that any who had previously used pneumatic hammers or had done grinding or similar work could be set apart. A general medical history was taken, and a full physical examination followed. Ætiological factors other than present occupation could thus be eliminated at the start. Finally, as a rough clinical test, each person was asked to sit with his or her hands immersed above the elbows in a trough of running water at 15° C. After 15 minutes the hands were dried and examined for visible confirmation of any claims of colour changes.

Of the original 246 males, thirteen were excluded because they had previously been subjected to vibration in earlier occupations. Of these, four had handled pneumatic tools, two had been " holders up " for riveters, six had worked at grindstones, and one had used some sort of rotating scurfing tool elsewhere under conditions difficult to define.

There remained 233 males to be considered, of whom 163 (69·9 per cent.) were judged to be suffering from attacks of Raynaud's phenomenon by that time.

Two of the forty-seven women were excluded, one because she had done grinding work, and the other because she had clearly been suffering from true Raynaud's disease even before she had started work. Of the forty-five who remained, twenty-one (47 per cent.) were judged to be suffering from attacks of Raynaud's phenomenon.

These figures suggest that in March, 1945, the incidence of Raynaud's phenomenon amongst those exposed to risk was at least 184 out of 278, or 66·2 per cent. In every one of these cases the vascular disorder had first appeared *after* using the portable tool in question. Without doubt, therefore, it should be considered of occupational origin.

All the initial interviews were conducted during March and April, at the close of a moderately severe winter. It is necessary to record this fact, since the prevalent air temperature undoubtedly affects the severity of symptoms. Those who were questioned must have had in mind their recent experience of the cold weather, and they should easily have been able to recall a symptom such as blanching of the fingers, which in so many cases was brought on by it. Their answers might have been less informative if given at the end of the summer, at which time the less severely affected ones could have forgotten their symptoms or even have claimed to be cured. Notice must always be taken of the time of the

year, particularly when investigating the course of this disease.

The diagnosis had in many cases to be made on the history, and often on this alone. So great a reliance on history may be criticized, on the ground that the workpeople in this factory had little to lose, and indeed might have much to gain, by claiming symptoms. Indeed, their natural anxieties might have led to some involuntary distortion of the testimony. Nevertheless it was possible to test the validity of claims by cross examination. Self-contradictory histories were not encountered. The cold water immersion test in many cases confirmed the presence if not the extent of the lesion. In cases where it did not, the factory medical officer was sometimes able to say he had seen vascular disturbances on another day. The follow-up study more than confirms the high incidence of the condition.

Age Distribution.—It is necessary to determine the age distribution for both the affected and the unaffected workers lest this factor should have a bearing on the case incidence. Table 1 shows this distribution for males and females separately, and for the aggregate.

It appears that the age distribution is fairly comparable in the affected and unaffected groups. The age-group 40 to 49 (into which the greatest number of workers fell because of the nature of the labour force available) comprises a somewhat disproportionate number of affected men, it is true, but this high proportion is not seen in the next oldest group and may therefore be fortuitous. Amongst the women the highest relative incidence of disease is in the age-group 20 to 29, but the numbers are too small for any conclusion to be drawn from this. It is clear from Table 1 that Raynaud's phenomenon due to the use of this particular tool is not confined to the older workers, as would have been expected had the phenomenon been directly related to the progressive vascular changes of advancing years.

Past History and Family History.—Particular enquiry was made for any past history of vascular disorders or "bad circulation." A few admitted to seasonal perniosis in one form or another, but none would say that they had ever noticed blanching of fingers even after sea-bathing, which is commonly a precipitating event in normal people who occasionally experience "deadness" of a finger. Only two out of the whole series knew of such blanching in other members of their families.

It was unexpected to find so few giving a positive history in these respects. Lewis and Pickering (1934) contended that a positive earlier history could be obtained from 25 per cent. of normal men and 30 per cent. of normal women, and that, of these, 50 per cent. could be expected to give a positive family history. They also found that such attacks were usually experienced in youth. It may be that the older people in the present series had forgotten such minor occurrences. Otherwise these negative findings can only be explained as a local variation or as an involuntary distortion of the facts because of anxiety about the immediate symptoms. The latter is the more understandable explanation.

Symptoms.—The common complaint was of numbness or "deadness," or that there were from time to time changes of colour in the fingers, extending proximally from the tips. One or two of the men first affected in this outbreak had also complained that their fingers became "locked" round the handpiece and could be freed only by passively straightening the fingers with the disengaged hand. Particular watch was kept for this latter symptom because it had been reported by the Trades Union representative and was considered likely to cause accidents. Only two men appeared definitely to have experienced it, while two other men and two women were doubtful. Several men talked of "a continuous ache" in the muscles of the ulnar border of the forearm, coincident with the blanching of the

TABLE 1

TO SHOW THE AGE DISTRIBUTION FOR AFFECTED AND UNAFFECTED WORKERS

Age in Years	Men		Women		Total	
	Affected	Unaffected	Affected	Unaffected	Affected	Unaffected
19 and under	0	1	0	0	0	1
20–29	11	5	12	8	23	13
30–39	35	19	6	13	41	32
40–49	82	28	3	3	85	31
50–59	34	18	0	0	34	18
60 and over	1	0	0	0	1	0
Totals	163	71	21	24	184	95

fingers. This appeared to be in the nature of ischæmic cramp, but it was too ill-defined to be of help in localizing the actual site of a vascular lesion.

The Effect of Cold.—The relationship of the blanching and numbness to cold was very definite. Usually this information was volunteered, and early rising in winter or washing in cold water were both held particularly responsible. Altogether 145 (89 per cent.) of the affected men and 14 (67 per cent.) of the affected women agreed that cold was the chief precipitating factor. Eleven people denied that it was of any significance, and the remainder were uncertain.

Provided that the workers could keep warm it was to be expected that they would not suffer attacks while at work, and that loss of time and wages would be small. In fact only twenty-six (16 per cent.) of the affected men and six (29 per cent.) of the women had ever experienced attacks while actually working. One or two claimed to have had attacks only when starting a shift, that is, when the tool was cold to the touch. One man found it necessary to grasp a nearby electric light bulb to put an end to the attack which he always had on arriving at work in the morning.

Other Symptoms.—Pain, apart from the forearm cramp already mentioned, was an unusual symptom ; but loss of sensation was always noticed during attacks, and many men complained that they dropped their morning papers at breakfast. None spoke of a loss of the ability to grip : without this ability their work could not have been attempted. Several had noticed attacks coming on when they were carrying heavy weights. Nearly all the workers were smokers, and the effect of tobacco, therefore, could not be judged.

" Handedness."—One hundred and fifty-seven of the 163 affected men were right-handed. This means that they usually held the tool with the left hand in front, nearest the cutting head, as has been described. Of these 157, 134 were first affected in the left hand, while eight were simultaneously affected in both. Only three men were left-handed, and they held the tool in the reversed position with the right hand in front of the left. Two of these three were affected first in the right hand, and one in the left. The three men remaining were ambidextrous and held the tool either way at will : two of them were affected first in the left hand and one in the right. The affected women were all right-handed : eighteen of them were initially affected in the left and three in the right.

Handedness is, therefore, of considerable significance. Using the natural handedness (or dominant hand) as the criterion, it will be seen that 154 (83·6 per cent.) were affected first in the contralateral hand, and twelve (6·5 per cent.) first in the ipsilateral. In other words, in 83·6 per cent. of cases the hand nearest to the cutting head was affected alone or first of the two. This suggests that it receives the most vibration.

Duration of Exposure to Risk.—The average time elapsing between the start of scurfing work and the first appearance of symptoms was (for the 163 affected men) 23·5 months, but there was wide variation from a minimum of two months, to a maximum of four years. The average time in the case of the affected women was 20·6 months, which is not appreciably different, and the limits were eight months and forty-five months. As many as thirty-three of these men and women had already suffered their first attack before they had completed a year of scurfing work. It had been tentatively suggested to the management of the factory that one year's service should be laid down as the maximum for any worker, but it is clear that this would by no means have solved the problem.

TABLE 2

DURATION OF SCURFING WORK REQUIRED TO PRODUCE THE FIRST SYMPTOM, COMPARED WITH THE AGES OF THE VICTIMS, MALES AND FEMALES BEING TAKEN TOGETHER

Age (years)	Months of Work							
	0–6	7–12	13–18	19–24	25–30	31–36	37–42	43 and over
20–29		× × × × × × ×	× × × × × ×	× × ×	×	×	× ×	×
30–39	× × × ×	× × × × × × ×	× × × × × × × ×	× × × × × ×	× ×	× × × × × ×	× × × × ×	×
40–49	×	× × × × × × × × × ×	× × × × × × × × × ×	× × × × × × × × × × × × × × × × × × ×	× × × × × × ×	× × × × × × × × × × × × × × ×	× × × × × × × × ×	× × ×
50 and over	× × × × ×	× × × × ×	× × × ×	× × × × ×	× × × × ×	× × × ×	× × × × ×	×

The distribution of cases by age and by duration of exposure to risk before the onset of symptoms can be seen at a glance, from Table 2. Duration of exposure to industrial hazards often goes hand in hand with age, but that was not the case in this factory because scurfing and polishing work had been introduced only recently, the training required was short, and the workers had been drawn from a mixed population of all ages.

The table shows a fair uniformity of distribution. There is a tendency for those in the youngest age

group to have been exposed to risk for the shorter periods. In the age-group 40 to 49 years, where the majority of cases lay, the greatest number was in the exposure-period 19 to 24 months, that is, scattered round the mean exposure period for the whole group, men and women together. This was only to be expected. The distribution is remarkably uniform in the oldest age group. The general appearance of this Table suggests that when age is to be compared with severity of lesions or other variables, the effect of length of exposure can reasonably be ignored. The converse appears equally true.

Up to the time of the first enquiry the mean duration of employment on scurfing work for the workers who had *not* been affected was 25·7 months in the case of the men, but the time varied between one week and five years. In the case of unaffected women the mean was 24·8 months, the limits being one month to forty-six months. This "unaffected" group naturally contained newcomers, some of whom had obviously not had sufficient time to develop symptoms; despite this, the mean exposure of the unaffected subjects was longer than the mean time taken to produce symptoms in the rest. Indeed, four of the unaffected group had worked longer than the maximum time so far taken to produce symptoms in anyone. Provided that other factors are equal, this suggests that there may be certain people who are insusceptible to the disease. The reason for such an insusceptibility is not easy to see, nor is it predictable in any individual case. A parallel can be drawn in other occupational diseases.

Anatomical Distribution of the Disorder.—Ninety-two of the men and fifteen of the women had so far been affected in one hand only. The remainder (seventy-one and six respectively) had already had both hands involved, and the average total time of working before the disease became bilateral was 28·4 months for men and 25·7 for women. The second hand had become affected at any time up to twenty-four months after the first (mean = 6·6 months) in the case of the men, and at any time up to twelve months after (mean = 7·5 months) in the case of the women. As already stated, in fifteen cases the first signs were seen in both hands simultaneously.

In spite of the large number of diseases with which Raynaud's phenomenon is associated—and Hunt (1936) lists sixteen—any ætiological factor which might be common to all remains undiscovered. The outbreak at present under discussion is one of the few in which a tangible ætiological factor, namely vibration, has presented. It therefore becomes increasingly important to record the exact extent of the vascular disorder of function, for the distribution may vary in other occupations in which a different quality of vibration is encountered.

There was no example, in this series, of vascular disturbances involving the toes or feet. In the hands the colour changes were invariably distributed centrifugally. It was usual for the earliest attacks to involve the tips of the fingers only: if the disease then progressed, the spread was centripetal, but progressive "deterioration" in this respect was by no means the rule. Blanching of the whole length of a finger was sometimes seen from the first attack onwards.

In some cases precisely the same areas of the hands were affected at every attack: in others a mild attack would affect only the tips, but a more serious one usually involved a much greater area. It is not possible to show whether this variability is due to arterial spasm changing in site according to the degree of chilling, or whether it is due to varying degrees of occlusion of an artery by spasm at some fixed point which is proximal to the site of the blanching itself.

The patients always described the extent of the colour changes by reference to the various joints of the fingers. This has suggested a shorthand system of notation which proves of considerable practical value. For the purpose the digits are numbered 1 to 5, from the thumb to the smallest finger. One stroke after the number then indicates colour changes extending from the tip to the distal interphalangeal joint; two strokes indicates from tip to proximal interphalangeal joint, and three strokes (e.g. 5′′′) the whole finger to the metacarpophalangeal joint. The unit is thus the length of one phalanx. According to this notation a lesion in the left hand which involved the distal phalanx of the thumb and the whole length of the middle and ring fingers would be expressed as follows:

Left .. .. 1′ 3′′′ 4′′′

while total involvement of all digits in the right hand would be:

Right .. .. 1′′ 2′′′ 3′′′ 4′′′ 5′′′

In some accounts of Raynaud's phenomenon it has been suggested that the thumb is not involved. Initially nine workers, all men, were found to have involvement of one thumb, while two others had both thumbs involved. Two and a half years later the number had increased to forty-eight, and the occurrence was no longer confined to men. Furthermore, amongst these forty-eight were now twenty with bilateral thumb involvement. This total of forty-eight cases shows that in 17·3 per cent. of the whole series of workers the thumb was involved.

TABLE 3

PROPORTION OF CASES IN WHICH THE VARIOUS FINGERS WERE INVOLVED AT THE *first observed attack* OF BLANCHING

	Men (Total = 163)					Women (Total = 21)				
Digit affected ..	Thumb (%)	In ex (%)	Middle (%)	Ring (%)	Little (%)	Thumb (%)	Index (%)	Middle (%)	Ring (%)	Little (%)
Contralateral hand	0·6	26·4	54·6	57·0	31·3	Nil	14	24	52	19
Ipsilateral hand ..	Nil	6·7	7·4	6·7	4·9	Nil	Nil	5	14	Nil

Each subject was asked to recall the first attack he or she had experienced. No one had difficulty in indicating the extent of the disorder on that occasion, though in some cases it had occurred four years before. A better indication could scarcely be given of the concern with which a working man regards the first sign of " deadness " in his fingers. The natural handedness of workers has already been shown to be of significance. It is convenient to use the same criterion of " handedness " when considering which of the various fingers were affected at the first observed attack of blanching. This has been done in Table 3, in the cases of the 163 men and twenty-one women found to be affected. In most of them more than one digit was involved.

Most of the men and women, therefore, saw the first evidence of abnormality in the ring and middle fingers. This could mean that these fingers were subjected to more serious trauma than the others, or that the arterial branches supplying them were unusually sensitive to a general vascular disturbance, whatever it might be, or to the precipitating action of cold.

The distribution of lesions at the time of the first interviews in March, 1945, already demonstrated an increase in the extent of the involvement, as Table 4 shows. It was found to be very similar for males and females, so the figures of the two have been combined. The Table therefore concerns a total of 184 cases, and the proportions are expressed as percentages of that number.

The general trend of the figures in this Table agrees with that in the last. The rate of increase of the lesions cannot be computed from them, however, for Table 4 relates to one definite date, whereas Table 3 is drawn up irrespective of dates, because it refers to the first experience of blanching in individual cases. Nevertheless, Table 4 does show that, by March 1945, 89 per cent. of the affected subjects had involvement of the tip of the ring finger in the contralateral hand (which in most cases was the left) : over half had involvement of the whole of that finger. The incidence was much less in the right hand, but relatively it was heaviest in the middle and ring fingers, as before.

As far as individual sufferers were concerned, many different combinations of affected fingers were

TABLE 4

PROPORTION OF CASES IN WHICH THE VARIOUS UNITS OF THE FINGERS WERE INVOLVED BY THE TIME OF THE INTERVIEW IN MARCH 1945

Digit		Thumb (%)	Index (%)	Middle (%)	Ring (%)	Little (%)
Contralateral hand	Tip to distal interphalangeal joint	—	57·0	87·4	89·0	70·7
	Tip to proximal interphalangeal joint	6·0	47·6	75·0	78·8	60·8
	Tip to metacarpo-phalangeal joint	0·5	27·7	43·9	52·1	42·3
Ipsilateral hand	Tip to distal interphalangeal joint	—	22·2	25·5	27·7	17·9
	Tip to proximal interphalangeal joint	2·2	17·9	16·8	22·3	14·1
	Tip to metacarpo-phalangeal joint	0·5	6·0	7·1	8·7	7·6

found in the present series, but never once were thumb and smallest finger affected together if those between them were normal. Often adjacent fingers were involved, and then the middle one of a group was frequently worse affected than those outside as, for example, in Case 242 :

Left .. .. 2′′ 3′′′ 4′′

Sometimes a single finger escaped in spite of involvement of those on each side, as in Case 233 :

Left .. .. 2′′′ 4′′′

but the commonest distribution was involvement of several fingers all to the same degree :

Case 47 : Right .. .. 2′ 3′ 4′
Case 245 : Left .. .. 3″ 4″ 5″
Case 72 : Left .. .. 2′′′ 3′′′ 4′′′ 5′′′

Involvement of the Palm.—Vascular disturbances were not only confined to the fingers and thumb. Five men, all of whom had been engaged in the heaviest kind of scurfing work, had had attacks which extended from the finger tips into the palm of the hand. The distributions in these cases were as follows :

Case 27.—Attacks in the left hand involved the thumb, all the fingers, and the palm to a horizontal line from the root of the thumb, that is, 1½ inches proximal to the web of the fingers.

Case 28.—The middle, ring, and index fingers of the left hand were involved, and also the palm to a line extending from the root of the middle finger diagonally across to a point on the ulnar border of the hand two inches proximal to the root of the little finger. This claim was amply confirmed when the man's hands were immersed in cold water.

Case 147.—The distribution was the same as in Case 27 except that the thumb was unaffected.

Case 228.—It was said that blanching took place in the middle, ring, and little fingers of the left hand and extended proximally "as far as the wrist," though the thumb, index finger, and radial half of the palm were, seemingly, unaffected. This claim could not be fully substantiated by the immersion test but, as will be shown, this fact does not discredit it entirely.

Case 231.—The distribution was exactly similar to that in Case 28.

This evidence suggests strongly that temporary occlusion can take place in the common digital and metacarpal arteries at least as far proximally as the points where they arise from the palmar arches ; it also suggests that both these sets of arteries are affected simultaneously.

Cyanosis.—Those who had noticed colour changes usually spoke first of "whiteness" or "waxiness" of the fingers. This whiteness would eventually give place to red and white mottling, or to the uniform bright red colour which is evidence of reactive hyperæmia. The last stage is often accompanied by unpleasant sensations of "prickling" or "tingling," and sometimes even of acute pain. Indeed, such discomfort usually heralds the return of normal circulation. Many of those who were affected described in addition a succession of colour changes from "whiteness" to "waxiness," to "blue," "grey-blue," "blue-black," or "black," before the return to redness and normality after a variable delay. Others used the words "dusky," "leaden-blue colour," "violet," or "purple." Descriptions of this kind obviously imply a stage of cyanosis of the fingers, and this could be seen in many cases during the immersion test.

TABLE 5

INTERVAL ELAPSING BETWEEN THE ONSET OF BLANCHING AND THAT OF CYANOSIS IN A SERIES OF MALES, BY SIX-MONTHLY PERIODS

	Interval (months)				Total subjects
0 (simultaneous)	1–6	7–12	13–18	19–24	
18	44	18	11	6	97

Hunter, McLaughlin, and Perry (1945) observed that cyanosis was uncommon in cases of Raynaud's phenomenon brought about by the use of pneumatic hammers. Nevertheless cyanosis was far from rare in the present cases, for 111 (68 per cent.) of the affected men and twelve (57 per cent.) of the women described it in a way which left no doubt of the matter. The onset of cyanosis in relation to that of blanching in the case of the ninety-seven men who could give precise dates repays study. Eighteen of them said that cyanosis had appeared at the very first attack of vascular disturbances. Never, on the other hand, had it been delayed longer than two years after the first attack of simple blanching. The distribution is shown in Table 5.

The mean interval was 6·4 months. It may be objected that cyanosis could have appeared in many more of the men who already experienced attacks of blanching, had they been longer at the work. Table 6 suggests that this may indeed be the case. It shows the time which had elapsed between the onset of symptoms and the date of the enquiry (March, 1945) for the fifty-two men (163 minus 111) who talked of blanching but had not noticed cyanosis.

Since twenty-eight of these men had only experienced attacks of blanching for six months or less, it is to be expected that some at least of them would exhibit cyanosis if watched for a further eighteen months.

TABLE 6

LENGTH OF PERIOD OF OBSERVATION FROM THE FIRST ONSET OF BLANCHING IN THE CASE OF MEN *not* EXHIBITING CYANOSIS

Period of Observation (months)					Total subjects
1–6	7–12	13–18	19–24	25–30	
28	12	6	4	2	52

The tendency towards cyanosis might perhaps be related to age of the subject. This could be tested by observing the incidence of cyanosis in two groups of men in separate decades, provided that they had had comparable exposure to risk. Table 2 on page 150 (which is, however, drawn up to include women as well as men) suggests that the decades 30 to 39 and 50 to 59 years might be sufficiently comparable. Table 7 shows that two closely comparable groups do result if those males in these two decades who have done more than six months' scurfing work are considered. It is, therefore, permissible to compare the incidence of cyanosis in the two age groups.

This suggests that there is some tendency, provided that exposures to risk are comparable, for the younger men to exhibit cyanosis more often than the older.

It has already been suggested that cyanosis is the more to be expected the longer a man suffers attacks of vascular disturbances; likewise, there is already good evidence that the anatomical extent of the lesions increases the longer a man continues in this work. A tendency to cyanosis should, therefore, go hand in hand with the clinical severity of the lesion if the latter is measured in terms of anatomical extent. From many points of view it is useful to measure "severity" thus, because its assessment depends only upon an accurate anamnesis—which is not difficult to obtain in this disease: records, moreover, are simple to keep, and comparisons easy to draw. It is certainly the measurement which seems most logical to the patient.

TABLE 7

SIMILARITY OF TWO AGE-GROUPS OF MEN IN RESPECT OF LENGTH OF EXPOSURE TO VIBRATION, AND INCIDENCE OF CYANOSIS IN THE TWO

Exposure to vibration (months)	Aged 30 to 39		Aged 50 to 59	
	Total	Cyanosis	Total	Cyanosis
7–12	5	4	5	0
13–18	6	2	4	2
19–24	7	7	5	3
25–30	3	2	5	4
31–36	5	5	3	1
37–42	5	3	7	5
43 and over	0	0	1	1
Total	31	23	30	16
Cyanosis	74 per cent.		53 per cent.	

To make it possible to compare proclivity to cyanosis with severity of lesion, the index of severity arbitrarily chosen here is the extent of vascular disturbances in the *worst affected* of the hands. As before, this can be expressed numerically as the aggregate number of "units" or joints of finger involved. The resulting figure will be called the "index of severity." Thus, complete involvement of all fingers and thumb calls for an index of severity of 14. It would have been equally feasible to take as the index the aggregate of all the "units" involved in both hands, with a maximum of 28.

TABLE 8

TO SHOW THE PERCENTAGE OF CASES EXHIBITING CYANOSIS BY GROUPS ACCORDING TO SEVERITY OF LESION

Index of severity (units)	No. of cases	Cases with cyanosis	Percentage with cyanosis
1 and 2	7	1	14
3 ,, 4	20	7	32
5 ,, 6	39	23	59
7 ,, 8	23	17	74
9 ,, 10	39	30	79
11 ,, 12	31	29	94
13 ,, 14	4	4	100
Totals	163	111	68

However, a lesion of 14 units in one hand appears, to the patient and other observers alike, to be of more consequence than one of 14 units divided between the two hands.

Cyanosis and severity are compared in Table 8, which shows convincingly that the tendency to exhibit cyanosis bears a direct relationship to the severity of the disease expressed in terms of its anatomical extent.

Immersion Test.—The procedure adopted for this test has already been briefly described. It cannot be compared in accuracy with the usual thermometric laboratory tests of the reaction of vessels to cold. Nevertheless it was simple to use and adaptable to the cramped conditions of a factory first-aid post, provided that running water was available. One advantage was that it took only fifteen minutes to perform, for speed is a matter of importance in dealing with a group of men and women who are anxious to lose no more working time than is necessary. The test allowed the observer some chance of reproducing artificially the vascular disturbances about which he was being

told. It was open to the objection that the experimental conditions could seldom be kept constant. A deep sink provided with running water from the mains, the temperature of which varied no more than 1° C. from day to day, ensured uniformity in the local application of cold. But the temperature of the room varied considerably throughout the day, and the outside air through which the subjects walked for varying distances to come for interviews was of even less uniform temperature. Some subjects protested that their test would show nothing abnormal because they were thoroughly warm from hurrying to the examination; and in several such cases it was negative. Others said that no signs would appear on immersion because their hands had only just recovered from an attack of blanching. Such an occurrence would suggest that a refractory interval exists after the spasm in an artery has been relieved. Negative tests in two severe cases, which otherwise might have been expected to produce blanching easily on immersion, lent support to this idea. More accurate tests under laboratory conditions are needed to establish it.

In order to evaluate the immersion test it is, of course, necessary to accept without question the testimony of patients regarding the presence or absence of attacks of Raynaud's phenomenon. The assessment cannot be entirely objective.

A positive result was recorded in all cases where there was blanching or cyanosis of orthodox distribution, with a distinct line of demarcation between normal and abnormal skin colour. Seven out of the twenty-one women who said they were affected showed a positive immersion test, but it is not profitable to analyse this small number further. Of the 163 men who considered themselves affected, 111 (68 per cent.) had a positive test. These were not the same 111 individuals who gave a history of cyanosis (see p. 153): the exact similarity of the number is fortuitous. The area of the disturbance shown in the test never appeared as extensive as that described in the history. Cyanosis during the test was actually observed in sixty-three out of this group of 111. On the basis of the history they gave, eighty-eight out of the 111 *could* have exhibited cyanosis, so in this respect the test reached 72 per cent. of expectation.

A positive result to the test was more often obtained in the severe cases than the mild. This is well shown in Table 9, which compared the percentage of positive immersion tests in groups arranged according to the "index of severity," as previously defined, based as before on the subjects' histories.

This Table also illustrates the difficulty of interpreting the test when lesions of only slight or moderate degree of severity are being claimed. A positive test supports a claim of vascular disturbance incontrovertibly, but a negative one will not prove that the claim is false. Great care must clearly be exercised in using test as additional evidence in a case which has become the subject of litigation. In less controversial circumstances the immersion test appears to be useful. A diagnostic aid of such simplicity as this should not perhaps be lightly condemned on grounds of the inconsistency of its results, since its limitations can be defined, on the evidence of Table 9. Probably the full extent of the lesion claimed will not be reproducible under consulting-room conditions, so a test should be called positive on the mere presence of colour changes, not on their extent.

TABLE 9

INCIDENCE OF POSITIVE IMMERSION TESTS COMPARED WITH THE "INDEX OF SEVERITY"

Index of severity	No. of cases	Cases with positive immersion test	Percentage with positive test
1 and 2	7	3	43
3 ,, 4	20	9	45
5 ,, 6	39	26	67
7 ,, 8	23	16	70
9 ,, 10	39	27	69
11 ,, 12	31	26	84
13 ,, 14	4	4	100
Total	163	111	68

Effect of Variations in Type of Work on Incidence of Disease.—An attempt must be made to correlate the incidence and severity of the lesions with the various types of work which were being done in this factory with rotary hand tools.

Certain of the women had been called upon to use only the smallest cutting "heads." Though this should have been in theory an important group to study, it was too small to enable useful conclusions to be drawn. A second group of workers had changed too often from one type of head to another.

A third group consisted of men who had been employed all the time in polishing steel crankshafts either with "buffs" made of felt dressed with emery powder, or with small silicon carbide stones. Women did not do such work. The twenty-four men concerned were mostly between the ages of 40 and 53. Only ten of them were affected, and the lesions were of all degrees of severity. The incidence of Raynaud's phenomenon (42 per cent.) amongst them is considerably below the incidence (69·9 per cent.) for the whole male series. The period during which they were exposed to risk before the onset of

symptoms varied from twelve to forty-eight months, with a mean of 23·5 months. This is the same figure as for the male series as a whole. It seems unlikely that most of the fourteen unaffected men in this group had escaped trouble simply because they had not been at risk long enough, for their average exposure to vibration was already 27·1 months. The available evidence suggests that the task of polishing crankshafts is somewhat less likely to produce Raynaud's phenomenon than the other operations, but that the nature of the lesion is not appreciably different when it does appear.

The last which will be considered is a group of eighty-nine men who had spent the greater part of their time scurfing with the largest of the cutters. This was without doubt the most arduous of the scurfing work. These men were of all ages, and

TABLE 10

DISTRIBUTION OF THE SEVERITY OF LESIONS IN THE WHOLE SERIES COMPARED WITH THAT IN A GROUP OF MEN SOLELY EMPLOYED ON LARGE CUTTING HEADS

Index of severity	Whole series (expressed as a percentage of a total of 163)	Series of men using large cutters only (expressed as a percentage of a total of 80)
1 and 2	4·3	3·8
3 ,, 4	12·3	8·8
5 ,, 6	23·9	21·2
7 ,, 8	14·1	15·0
9 ,, 10	23·9	25·0
11 ,, 12	19·0	22·5
13 ,, 14	2·5	3·7
	100·0	100·0

eighty out of eighty-nine (90 per cent.) were affected. Furthermore, sixty-five of these eighty men (81 per cent.) had observed cyanosis during their attacks. The incidence of blanching and of cyanosis is thus higher than in the whole group, where the figures were 69·9 per cent. and 68 per cent. respectively. Once again the mean duration of exposure to risk before observing symptoms, namely 23·6 months, was scarcely different from the mean for the entire series. The severity of the lesions in these eighty men can be compared with that for all the males in the series, as in Table 10, using the index of severity already described.

The distribution of cases by severity agrees closely in the whole series and in the part.

There is thus evidence to suggest that working with large cutters makes for a higher total incidence of vascular disorders, but that these do not arise any more rapidly, nor are they appreciably more extensive than in the series as a whole.

Other Clinical Findings.—There were few abnormalities apart from those in the peripheral vascular system, but it is of importance to record the negative findings briefly.

There was no evidence of local skin lesions on the fingers or hands, none of trophic changes, and none of sclerodactyly. There was no sign of the permanent occlusion of any vessel, large or small, and no suggestion of impending gangrene. The radial pulses were palpable in all cases. Benign hypertension was discovered in twenty-seven cases, but it was never severe: a raised blood pressure did not seem sufficient abnormality by itself to warrant the exclusion of a case from the series. Raynaud's phenomenon caused simply by arteriosclerotic changes is a rare enough happening.

Callosities were much in evidence on the hands, but they were not distributed in such a way as to become a definite stigma of this occupation.

One man had symptoms and signs to suggest osteoarthritis of the shoulder-joints, but evidence of arthritis was otherwise lacking. There was no wasting of the small muscles of the hands. The neurological examination was always negative, except for a relative hypalgesia at the finger tips when these were cold: the hypalgesia did not seem to be confined to the fingers which had been reported abnormal. There was nothing to suggest that any patient was suffering from a cervical rib, but radiographs of the neck were not taken. The incidence of Raynaud's phenomenon was very high in this series, and it is scarcely likely that a significant number of cases could have been due to undetected cervical ribs. Blood counts, Wassermann reactions, and radiographs of the wrists or carpal bones were not attempted.

THE COURSE AND INCIDENCE OF THE DISEASE: LATER FINDINGS

An interval had now to pass before the progress or sequelæ of the disease in individual cases could be studied. In mid-summer 1947 it became known that the factory had closed down. The workers had dispersed to their normal peacetime occupations, and many had moved to other districts. A second personal interview with each was already out of the question. The longer the delay, the greater would this dispersion have been, so in September, 1947, two and a half years after the first examination, a circular letter and questionnaire were sent to all the workers concerned. A second physical examination was precluded.

The aim of the questionnaire was to decide, as far as is possible from any such enquiry by post, the following questions:

(*a*) What proportion of those who had previously escaped attacks of Raynaud's phenomenon had since become affected.

(*b*) Whether it is possible for the condition to appear after a worker had given up the work. (The fact that the works had shut down would make this easier to determine.)

(*c*) Whether the condition in those already affected was improving, remaining stationary, or deteriorating:

also, whether any relationship existed between the course of the disease and the cessation of scurfing work.

(*d*) Whether the anatomical extent of the disorder had increased in any cases, and whether any fresh symptoms had arisen.

(*e*) Whether any workers considered themselves handicapped by their condition, and if so, for what reasons. Any disability in respect of their new occupations was to receive particular attention.

Separate questionnaires were devised for those who had already been affected and for those who had not been subject to attacks of vascular disorders by the time of the first examination. Information was requested concerning the date of ceasing scurfing work, the nature of the subsequent employment, and the onset or cessation of attacks. The present anatomical extent of the lesion during a full attack was to be shaded in on the outline drawing of the hands which was provided. Further questions related to the events which brought on attacks and the progression of colour changes to be seen, while others sought a personal estimate of the improvement or deterioration, and the grounds for the opinion offered. Finally, each worker was asked whether attacks came on while the work was going on, whether they were causing hindrance and, if so, in what particular way. Space was left at the end for free personal comment. It was by then autumn, and a word of warning was added explaining that attacks would probably have been few in summer. Everyone was, therefore, asked to recall the previous winter's experiences before answering.

If the second enquiry had also been conducted in the month of March, it would have given results more comparable with those obtained previously. In view of the difference in season, the answers given in the 1947 survey make possible a conservative estimate of the later extent of the disorder and the disability it was causing to individual workmen.

Of the original 278 men and women making up the whole series, 189 (67·9 per cent.) completed and returned the questionnaire. Of the rest, three men were reported to have died of other diseases, while in thirty-one cases the papers were returned uncompleted because the addressee had moved and his whereabouts was unknown. No reply was obtained from the remaining fifty-five despite a second letter asking for co-operation. It is certain that some of these defaulters had filed claims for compensation and were anxious not to do anything which might prejudice their chances.

It is convenient to consider the findings separately for those with established vascular disorders at the first examination, and those without.

Group A : Those who were Previously Free from Vascular Disorders.—Of this group, sixty-one out of a possible ninety-four completed the questionnaire : but in three of the cases the information offered was too inexact to warrant inclusion. Less than half (twenty-seven) of them were still free from symptoms, and twelve of these were women.

These twenty-seven men and women who still gave a negative history had worked at scurfing for periods of between eight and fifty-six months, the mean being 32·4 months. Eleven of the fifteen males had either spent their time polishing crankshafts with an emery-dressed buff or had done light scurfing with only the smaller cutters : this indirectly suggests that work with the larger cutters is the more harmful, as already discussed.

Because of the closing of the factory, these twenty-seven symptom-free subjects had already given up this work for periods varying between nineteen and twenty-four months without the slightest abnormality having appeared.

The remaining thirty-one people in group A had developed symptoms since the original interview. It is unlikely that, without exception, all those who failed to return their questionnaires had also become affected in this interval ; it is equally unlikely that they were all still free from symptoms. In the former event those who remained persistently symptom-free could have constituted only 9·7 per cent. of the original series of 278 ; in the latter event, they could have constituted 22·7 per cent. In September, 1947, therefore, the true proportion of positive cases must have reached between 77·3 per cent. and 90·3 per cent. of the original total.

The individual histories of the thirty-one fresh cases were examined : attacks were nearly all attributed to cold, but five men specifically blamed certain actions, such as carrying buckets, which called for strong gripping by the affected hand. One man was sure that extremes of both heat and cold started off his attacks. The claims of these people to have suffered disability will be discussed below.

Group A cannot be left without reference to the fact that two of its members developed their first symptom in the very month in which they had stopped scurfing work and left the factory. A further eleven first saw the disturbances appear some time after they too had stopped. In two cases it was one month later, in two it was two months, and in four cases it was three months later. The remainder were affected seven, twelve, and sixteen months afterwards respectively. Therefore, it is quite certain that ceasing to work with vibrating tools does not guarantee freedom from vascular disorders in the ensuing months. At present no estimate of the maximum latent period can be made. There is evidence from one case that

symptoms can develop not in the first cold spell, but at an even later date after such work has been abandoned.

Group B: Those who were Already Suffering from Vascular Disorders at the First Examination.—From a possible total of 184, 128 replies (69·6 per cent.) to the questionnaire were received.

All but three of these patients were still subject to attacks of Raynaud's phenomenon, and of these, two had still been subject to them during the coldest part of the previous winter and might be expected, therefore, to have further trouble in the winter which was to come. Only one subject (Case 55) in the whole investigation could claim a complete cure after having watched events through a severe winter.

Each man and woman had been encouraged to make a personal assessment of the progress of the disorder. In 64 cases (50 per cent.) the opinion was that the condition was stationary. Eight subjects (6·3 per cent.) were unable to give a definite answer: apart from Case 55, a further nine (7·0 per cent.) felt that there had been some improvement, though symptoms still occurred from time to time.

The remaining forty-six (36 per cent.) claimed that their condition had deteriorated in the 2½-years interval, whether judged by the number or the duration of attacks or by the number of the fingers attacked each time. All these forty-six had stopped working with vibrating tools for from seven to thirty months, and had been hoping for some improvement as a result.

A general survey of these case histories left no doubt that it was common for the condition to have remained unchanged, that deterioration, too, was common, but that improvement in the interim was unusual, and a cure exceptional. Nevertheless, serious sequelæ such as trophic lesions, scleroderma, or gangrene were not reported. The profusion of personal comments offered makes it likely that such things would have been mentioned if they had occurred.

In short, on this and other evidence above, Raynaud's phenomenon of occupational origin shows a greater tendency to progress than to disappear, at least in the early years after exposure to risk. This is a fact which calls for early recognition.

Anatomical Distribution at the Second Enquiry.—The distribution reported in September, 1947, was compared with that of March, 1945. Of the subjects who had had both hands affected there were now five in whom the right hand had become normal. In contrast, there were thirty who had started with a unilateral lesion (usually on the left) and had had the second hand affected during the follow-up period, although in some cases they had already given up the work before this happened. Involvement of the second hand is, of course, a particularly noticeable event in the natural history of the disease, so that when reported it can be accepted as good evidence of an extension of the lesion.

There were a number of small changes in the anatomical distribution of blanching. In thirty-three cases, that is, in 25·8 per cent., of the follow-up series, one finger had improved whilst another had become involved. This is probably a greater number than could be explained by the personal inaccuracies of patients when observing and reporting their symptoms, particularly as in such cases the broad distribution in the rest of the hand remained the same.

The precise area involved was again expressed numerically in units of one phalanx and compared with the involvement on the earlier occasion. The mean increase or decrease was derived for the whole follow-up series by using the algebraic sum, to allow for individual cases in which there was improvement in one finger and deterioration in others. The mean figure for the change in all these 128 cases was +4·3 units; that is to say, on the average each patient was now having 4·3 more phalanges or nearly 1½ more fingers affected in each attack. This is direct evidence of the tendency of the disease to progress. The greatest single progression was one of twenty-five units; not only had the distribution increased in the left hand of the man concerned, but all the fingers and the thumb of his right hand had now become involved, although this hand had been normal in 1945.

Analysing further, there were twenty-two in whom the records showed that there had been a real diminution in the area affected; that is to say, in these cases there was "improvement." Only nine people, it will be recalled, claimed improvement from their own general observations, so an exact clinical record of the area involved at each stage is of value. The greatest single improvement was only of 7 units, and in only the one case already discussed (Case 55) was recovery complete. In six cases no change at all was observed in the 2½-years interval. In the remaining hundred cases the extent of the lesion had increased.

Precipitating Factors.—Cold was still considered the most important factor in precipitating attacks. There were some patients who suggested that they had only to grasp objects firmly for blanching to appear. This was a feature of the history which had seldom been observed before. Some had noticed that chilling of the body as a whole was of

as much significance in producing attacks as the coldness of the extremities themselves. Two men had experienced Raynaud's phenomenon after hot baths as well as after washing in cold water. This is a remarkable statement for them to have made, but they had recognized it as such and had enlarged upon it. At first sight it would appear that the trunk and extremities should be warmer after a hot bath than at any other time, but it is possible that in such circumstances the high rate of cooling, rather than the exact temperature of the body or limb at the time, leads to arterial spasm.

One man now complained that his attacks were precipitated by excitement. This is the only history of its kind in this series, but it has been observed before in other cases of Raynaud's phenomenon of quite different ætiology.

Frequency of Attacks.—It is difficult for most patients to give an estimate of the frequency of attacks, for they are seldom in the habit of recording them in a notebook. Many men were able to give broad estimates, and it was almost the rule for attacks to have occurred daily, or even many times a day, in the winter months. Ninety-three members of the follow-up series (72 per cent.), had had variable attacks during the summer also. A few had had daily attacks at all seasons, whatever the weather.

The comparative rarity of attacks during working hours has already been remarked upon in a previous section, where it was attributed to the warmth generated by the scurfing tool and the excellent conditions prevailing in the workshops. Once having left these conditions, however, the men began to complain more often of attacks while at their work. In 1945, 19·6 per cent. of those with vascular disturbances had made this complaint; in 1947 the figure was 79 per cent. of all those in the follow-up series who fall into Group B. As Group B is derived from the same population of workers, it is permissible to compare these proportions, although the figure of 79 per cent. would be too large if those who had this complaint should happen to have been more anxious to return the questionnaire than the rest.

Disability.

The well-recognized disabilities of occupational origin may be easy to assess, such as the loss of an eye or limb in an accident at work, or they may be difficult, as in the case of silicosis. But commonly they are long-standing or permanent disabilities which vary little from day to day. The victim is often unable or forbidden to continue at the work which caused his disablement.

With vascular disturbances which produce Raynaud's phenomenon it is a different matter. The disease does not necessarily prevent a man from continuing in the same work—as in the present series of cases—even though he may be advised against it. When the disability does appear, it is transient, being present one moment and relieved the next; also, it is dependent upon external factors such as season, climate, and room temperature.

In 1945 few of the workers concerned in this outbreak talked of disability. It is true that they expressed anxiety for the future besides annoyance that their fingers should go "dead" on cold mornings. But of disability, in the sense of loss of working time or efficiency, there was none; for no one was prevented from coming to work in the morning simply because of an attack of blanching of the fingers, and no one lost a full working day, much less several consecutive days, from this cause alone. Many, regardless of symptoms, would have been content to continue at this work indefinitely, but there was no more to be had. Eventually, therefore, the presence or absence of disability in these workpeople came to be determined simply by the nature of the work which they undertook afterwards. This is an unusual state of affairs which calls for further examination.

In the questionnaire of September, 1947, those affected were asked to say whether or not their attacks of Raynaud's phenomenon hindered them in their present work, and to give reasons. There were many answers in the affirmative, but those unsupported by reasons were disregarded. Sixty-five of them appeared to be supported by sound reasons unemotionally stated: they are given case by case in the Appendix. In some of them hardship is all too apparent, as in the case of a polisher of copper rollers who returned to his own trade only to find himself quite incapable of pursuing it: he was then aged 49 and he was not trained for any other work (Case 101). A postman (Case 45) described how he was obliged to seek relief from his attacks by asking at the houses he visited for warm water in which to wash his hands. One or two people volunteered an estimate of their weekly loss of earnings because of disability. Some had been forced to leave work of their choice for something they liked less well. Others were unemployed and considered themselves at a disadvantage in a competitive labour market. At least one man feared that he would be dismissed if his employer should see the extent of his disability.

There were a number of textile workers who claimed that their work was being hindered by their attacks, but they recognized that their loss of time or efficiency was usually confined to the mornings,

because they arrived at work with blanched fingers. The working temperature of the mill, which was high, eventually restored the circulation, and they would have no more attacks that day.

Sixty-three men and women denied being in any way hindered in their new employment. Many of them were working indoors, and some were at pains to explain that they had particularly warm jobs, such as stoking boilers or rivet-heating. Such men will remain free from symptoms only for as long as they are able to keep satisfactory employment of this kind.

A warm job is the solution to the problem of finding full employment for these affected workpeople, but many of the warm jobs are exceptionally arduous, uncongenial, or poorly paid. A worker who found himself restricted narrowly in the choice of an occupation might with some justice consider himself " disabled," whatever else he suffered.

Discussion

The claim of many of these people to be disabled cannot be disregarded. Nor is it right to ignore the fact that there are many hundreds of riveters, fitters, and grinders in Great Britain who, though affected by the same disorder, make light of their symptoms and continue at work for years. These latter have regular work of their own choice, and need for carrying it out a firm grip without particular delicacy of touch. As the vascular disorder has little effect on their grip, they do not consider themselves disabled. The temper of a group of industrial workers, itself dependent upon their sense of economic stability, may have much to do with their claims to disabilities. Thus, in a different outbreak (Agate, Druett, and Tombleson, 1946) the thirty-two who were affected had regular work, with every prospect of continuing it, and they hardly complained of disability.

The circumstances in the present outbreak were quite different. When first seen in 1945, the workers were already threatened with the loss of their jobs, and they cannot be blamed for being concerned at their symptoms : yet even then they were not claiming to be disabled from working. Later their disability claims reflect the variety of jobs to which they had moved. It is worth noting in how many jobs vascular disturbances are considered a handicap.

Moreover, though this handicap may never mean the loss of full days of work, it could cause in the aggregate several hours of lost time per week, with loss of efficiency, wages, and status.

At the time of the outbreak vascular disorders were not specifically scheduled under the Workmen's Compensation legislation then in force. Legal actions have since been brought against various employers on the plea that the disorder was the result of injuries received in accidents. Thus, in one such case, the verdict was finally given in favour of the workman, since the Court was of the opinion that each vibration caused by a rapidly rotating instrument was, as it were, an infinitesimal blow to the nerves causing an infinitely small damage to their tissues, in the end cutting off the flow of blood needed to keep the hand in a healthy condition. The mere fact that the breakdown did not occur until the cumulative effect of the tiny blows from the vibrations had produced a certain degree of alteration in the nerves, did not affect the character of the cause. It appears likely that any future claims made on the same grounds in the courts would be upheld. But few working men are willing to undertake the considerable financial risks of an action at law.

Whatever the legal interpretation of the cause of the disorder and the liability or otherwise of employers, the known facts demonstrate that vascular disorders can often be attributed to occupational factors, and to vibration in particular. The present outbreak was discussed in the House of Commons in November, 1945. In the course of replying to a question, the Minister of National Insurance said :*

> " I am advised that there is not sufficient evidence that Raynaud's disease is so specific to employment as to justify its inclusion in the Schedule of Industrial Diseases under the Workmen's Compensation Act."

There seems to have been some confusion in the terminology, for if the usual definitions are accepted, Raynaud's disease (sic) is not related to employment, whereas there is the strongest evidence of a specific occupational disease which causes attacks of Raynaud's *phenomenon*.

At present this disorder is not included in the list of industrial diseases for which industrial injury or disablement benefit can be claimed, as prescribed under the National Insurance (Industrial Injuries) Act 1946. Its inclusion would present peculiar difficulties. A new conception of compensatable disability would have to be admitted, since this disability when present is recurrent, yet it lasts only a few minutes or hours (not days) at a time. Moreover, if the victim tries one kind of work, the handicap may be serious, but if another, it may vanish. It would be logical, though scarcely practicable, to re-assess this disability with every change of occupation. The writer believes that, in spite of the difficulties of including Raynaud's phenomenon of occupational origin with the other prescribed diseases, and in spite of the danger of such action leading to abuses and unnecessary

* See *Hansard* for Nov. 8, 1945.

claims, some consideration should be given to the difficulties under which the genuinely handicapped are labouring.

Three points in particular arise from the clinical study. First, the very high incidence of the disorder amongst the population at risk. Secondly, the frequency with which pallor was observed in attacks some months before cyanosis first appeared. Once cyanosis had appeared it was seen again at nearly every subsequent attack. The third observation is that the arterial spasm, which is usually taken to be the disorder of function, may vary in site from time to time in the same subject; in some, the involvement of the palm suggests spasm in an artery proximal to the digital vessels. Barker and Hines (1944) published an arteriogram of the hand in a pneumatic tool worker in which occlusion of the ulnar artery at the wrist is clearly shown.

Agate and Druett (1947) recorded the vibration spectra of a number of different tools and concluded that the most harmful vibration lies in the range of 40 to 125 cycles per second, particularly if the amplitudes in that range are of the order of 100 microns or more. The same paper shows that the rotary tool now in question produces appreciable vibration in that very range, whatever the working conditions are.

Elimination of harmful vibration from tools must in the end be the concern of engineers, for absorbent materials and other protective devices are not effective.

Summary

A fresh outbreak of cases of Raynaud's phenomenon has lately occurred in which the victims were men and women who had the job of polishing metal castings with a rotary tool. The characteristics of this tool and methods of using it are described.

As many as possible of the workers were interviewed and examined, and 278 valid case histories have been analysed. On the first survey 69·9 per cent. of the 233 men and 47 per cent. of the forty-five women were found to be suffering from attacks of Raynaud's phenomenon: these attacks occurred in workers of all ages over 20, and were precipitated by cold. As a rule a worker's dominant hand was affected less often, later, and less severely than the other, because of the way the tool was held.

The average time taken for a man to develop symptoms was 23½ months: this was independent of his age. When both hands were involved, as was the case in 43·5 per cent. of the patients, the second one was affected after an average delay of 6·6 months.

A convenient system of notation for recording the anatomical extent of the lesions is described. The ring and the middle fingers were most affected.

The occurrence of cyanosis during attacks is discussed. It usually appears about six months after the first evidence of blanching. Younger men may be somewhat more prone to cyanosis than older ones. The incidence of cyanosis in various groups is compared with the severity of the lesion, using an arbitrary "index of severity," and a direct relationship between them is shown to exist.

A simple diagnostic aid in the form of a cold-water immersion test is described, and its practical limitations and interpretation are discussed. The likelihood of a positive result to the test is directly related to the extent of the blanching as described by the patients. The effect of variations in the type of work on the incidence of disease is shown. Light polishing of steel components produces a relatively low incidence of lesions, whereas scurfing of duralumin with large toothed cutters causes an exceptionally high incidence.

Two and a half years after the first enquiry a questionnaire was circulated, and the course of the disease has been estimated from the answers returned. This was made necessary because of the closure of the factory and the scattering of the workers. Answers to the questions were received from 67·9 per cent.: 11·2 per cent. could not be traced through the post, and the rest failed to reply. A small proportion were still without symptoms but others, previously normal, were now suffering attacks. It is estimated that between 77·3 and 90·3 per cent. of the original 278 had now become affected by the disorder. In eleven cases the first symptom had been noticed after exposure to vibration had ceased.

Half of those who had been affected in the first place were of the opinion that their condition was stationary; 36 per cent. claimed that there had been deterioration in the interim; 4·9 per cent. were improved. One patient, a woman, claimed a spontaneous cure. In spite of small improvements in some cases, the anatomical extent had in the main increased. The workers' present claims to disability have been examined, and their own statements are appended. A number of these statements show evidence of hardship. Disability is claimed only in respect of a hindrance to effective working in certain specified jobs which these people have taken up since. The legal implications of this unusual state of affairs are discussed.

I wish to thank Dr. Donald Hunter, Director of the Department for Research in Industrial Medicine, for the kindness, encouragement, and inspiration he has given me. The Management and Workers of the Firm in question gave their fullest co-operation, and it is a pleasure to record my indebtedness to Dr. M. B. McCann,

then Senior Works Medical Officer of the Company. Professor E. D. Telford and Dr. F. H. K. Green kindly gave me very helpful criticism.

APPENDIX

STATEMENTS MADE BY 65 AFFECTED MEN AND WOMEN IN SUPPORT OF THEIR CLAIMS OF DISABILITY FROM ATTACKS OF RAYNAUD'S PHENOMENON CONTRACTED AS A RESULT OF THEIR PREVIOUS OCCUPATION

(Drawn from the questionnaires of September, 1947)

Case 2.—At present a *sales clerk*. He finds it difficult to concentrate during attacks and had to obtain special permission to have a fire during the fuel cuts of early 1947.

Case 3.—A *prepaid electric meter reader* who says that he is "handicapped in counting coins during the attacks." This is presumably due to loss of sensation.

Case 4.—A *newspaper shop salesman* who "cannot handle money during attacks."

Case 6.—A *housewife*. She claims "Difficulty in washing up and laundering during attacks. I have to wait for them to pass off." She is liable to attacks "several times daily" in winter.

Case 9.—A *progress clerk* who writes, "Lack of control and speed in writing and filing papers, but my employers have shown great consideration."

Case 14.—A *hire-car driver and mechanic*. He cannot handle cold spanners or wash down a car without attacks coming on. These jobs have had to be abandoned.

Case 22.—A *cloth salesman*. In cold weather bedspreads and blankets slip out of his hands when he is showing them to his customers.

Case 25.—*Unemployed*. He is a man of 57, now unable to dress himself in winter because of the anæsthesia experienced during attacks. He has not worked since 1945, but considers he would be able to work in summer provided that he does not have to touch bare metal or wet materials.

Case 26.—An *assistant spinner* who claims that he has "loss of sensitivity in the fingers regardless of attacks."

Case 29.—A *housewife* who says, "I cannot do washing or clean windows."

Case 32.—A man who is now *unemployed*. He had got work as a packer but soon had to give it up because the place was too cold and brought on attacks. He is sure that no employer would give him work if he heard about this disability.

Case 34.—A *dairyman*. He is a little handicapped by his attacks but remarks, "I don't say anything as I have six children to keep . . . very painful and unpleasant in winter."

Case 37.—A man who has become a *fruiterer* and who says, "I find work in the winter very difficult, having to wear warm gloves."

Case 38.—Now a *french polisher*. He is unable to grip anything during attacks.

Case 45.—A man who started as a *boiler fireman* but had to give up as his shovel flew out of his hand during the attacks. He has now become a *postman* and states that he cannot feel the letters in his fingers. "When delivering in cold weather, I ask the lady of the house to let me put my hands in warm water."

Case 47.—Now *unemployed*. He had just given up working as a labourer in a dyeworks because he had to work in water.

Case 53.—A man who has become a *bread packer*. Normally he handles six loaves at a time, but during attacks he can manage only three.

Case 57.—Now working as a *mule spinner*. He is worried because he uses the affected fingers for "piecing up." As the mill is warm, he only has trouble on arriving in the morning. He cannot work till the attack passes off, so in winter he has to arrive "very early" to give time for this to happen.

Case 67.—A man who has become a *window dresser*, but is hindered because he cannot handle glass shelves or display goods during the attacks, and these come on every day in winter.

Case 68.—*Unemployed* at present. He finds he "cannot take on a job unless it is in a warm atmosphere and away from water."

Case 69.—This man *handles furniture* and cannot trust his own grip. He says he is fortunate in having an understanding employer.

Case 78.—A man who is an *hotel porter* but is liable to drop baggage and crockery during his attacks.

Case 87.—A *weaver* who has to restore the circulation to her fingers before being able to start work.

Case 90.—A *cotton spinner* who, during attacks, has difficulty with piecing and taking in rim bands.

Case 96.—A *plater's mate* who describes in detail how the handling of cold spanners sets off attacks, and how while swinging his 7-lb. hammer he finds it slipping from his grasp. He often has to stop to warm his hands at the rivet fire to restore his circulation.

Case 99.—A man who is a *dress cutter*. During attacks he cannot handle fabrics, especially silk, because of the loss of sensation.

Case 101.—A man who for twenty-five years of his life has been a *polisher of copper rollers*. Since leaving the scurfing work he has returned to roller polishing, and finds the cold metal now brings on attacks of blanching. He fears accidents and will have to give up his only trade at the age of 49.

Case 102.—A *general labourer* who complains he cannot now handle a spade.

Case 106.—A *metal polisher* who has to stop working during attacks.

Case 109.—A *cotton operative* who, on every winter's day, is behindhand with his work between 7.30 and 9 a.m., at which latter time his fingers return to normal. This chain of events happens in spite of the warm temperature of the mill.

Case 121.—An *overlooker in a braiding mill*. He complains that his fingers are quite useless for the first thirty minutes of his working day, even in a warm room.

Case 129.—A *labourer in concrete*, out of doors. His grip is affected during attacks and he cannot handle a spade or wheelbarrow properly; moreover the attacks are painful.

Case 133.—A man who is a *roller and boner of bacon*. He states, "The bacon is nearly always in frozen condition and when the attack occurs it means I have to slow down until my fingers return to their normal state."

Case 138. A *woollen operative* who complains that he cannot change bobbins during an attack.

Case 141.—A *radial arm driller*. He finds that gripping the cold steel wheel of the drill feed initiates attacks, and these hinder him.

Case 143.—A *woodworker* who has to stop work to restore the circulation to his fingers. He is fortunate in being employed at a factory for disabled men.

Case 147.—A *window cleaner*, called upon to clean outside windows sometimes at a height of 100 feet. He is concerned at the loss of sense of touch in attacks.

Case 152.—A *fitter's mate on a railway breakdown gang*. On going out in wintry weather he finds that the handling of spanners and steel bars brings on attacks, and he has to stop work to warm his hands.

Case 157.—A *machine operator* who handles small objects. Her work is therefore liable to be hindered in cold weather when she suffers loss of sense of touch.

Case 161a.—A *ring spinner* who is hindered in taking off bobbins from spindles when she has blanched fingers.

Case 166.—A *sheet metal worker*. This man cannot hold tools or rivets during attacks and has to take special steps to warm his hands.

Case 167.—A *bus driver* who says, "If it does not improve in the next few days I shall have to ask to be relieved from driving, as I am afraid of losing control on the road."

Case 168.—A *bricklayer*. This man has been working indoors but still has attacks. He is incapable of handling bricks with his left hand for about two hours from the start of each attack.

Case 185.—This woman used to be a *cook* but has lost confidence in the grip of her hand since the attacks started. She is afraid to carry pans of hot water and fat, so she has given up her old job to become a *daily cleaner*.

Case 187.—Also a *cleaner*. She has to stop work to massage her fingers during attacks, which come on "often" in the winter.

Case 188.—A *cotton spinner* who is affected mainly in the left hand, and who happens to use this hand more than the right in her present work. The attacks come on while she is going to work and are terminated by the warmth of the mill.

Case 189.—A *plasterer* who complains that there are certain jobs he cannot do until the circulation is normal, and he wastes time in trying to restore it.

Case 194.—A man who has found a suitable job in the *vulcanizing shop of a rubber works*, but who had to give up his previous job as a *trainee moulder* in a foundry because the damp and cold brought on attacks.

Case 195.—A man who was a *packer*. He complains that he used to lose the sense of touch during attacks and so became a *handyman* instead.

Case 204.—A *labourer* in an electricity undertaking. Being now an outdoor worker he has more frequent attacks which are painful and make "handling" difficult.

Case 205.—A *furniture wood stainer*. He works with methylated spirit and naphtha, and says he "is like a man with one hand, as the left hand is practically useless."

Case 215.—A *labourer* in a steelworks. He claims that he dare not take on machine work now because of the vibration which would be involved, so he is "condemned to a weekly loss of £2 in wages."

Case 220.—A golf-course *groundsman* who, working out of doors, finds his hands going constantly "dead" and painful, so that it is impossible "to compete with fellow workers."

Case 223.—A *cotton mill labourer* who works in a cold place in the mill, gets attacks, and "has not the same earning capacity" as before.

Case 227.—A woman who was previously a *weaver* but who, though anxious to do so, cannot go back to work because "this is all finger work." She is even hindered in her housework by these attacks.

Case 228.—A *joiner* who is particularly impeded by not being able to hold nails between finger and thumb during attacks.

Case 233.—A *maker-up in a weaving shed* who for half an hour each morning finds that cloth is difficult to handle.

Case 236.—A *french polisher* who is impeded by the deterioration in his "touch." He finds that methylated spirit, with which he works, aggravates the attacks.

Case 238.—A *plaster moulder* who gets attacks because he constantly has to mix plaster with water by hand.

Case 240.—A girl who used to do *hand sewing* but cannot return to this. She estimates her weekly loss of earnings is 37*s*. 6*d*. as a result.

Case 242.—A *paperhanger and decorator* who cannot hold or feel wallpaper, or handle a brush during the many attacks he has in winter.

Case 255.—A *clothing inspector* who used to be a tailor but who has had to give this up owing to "loss of grip and feeling" in his hands.

Case 263.—A *livery stableman* who cannot feel his reins during attacks, which come on several times a day.

Case 274.—A man who is now content as a *packer*, but who had to give up his previous work as a *machine drill operator* because his hands were "useless" on arriving at work.

Case 286.—An *assembler of agricultural machinery* who fears dismissal as soon as his disability is discovered.

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SKIN SENSITIVITY TO CETRIMIDE (CTAB)

BY

C. N. D. CRUICKSHANK and J. R. SQUIRE

Medical Research Council Industrial Medicine Research Unit, Birmingham Accident Hospital

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CTAB—cetyl trimethyl ammonium bromide—was first introduced as a combined cleanser and skin antiseptic by Barnes (1942). It was subsequently incorporated in the Glasgow No. 9 cream for the treatment of burns (Colebrook and others, 1945). After bacteriological and clinical trial it was advocated for the initial treatment of wounds by Williams and others (1943, 1944). Both Colebrook and Williams reported cases of skin sensitivity to CTAB. The former worker, in a series of 2,000 burns treated with CTAB, noted only three cases of skin reaction; the latter, after patch-testing volunteers, concluded that the risk of skin sensitization to CTAB was slight.

Since 1944, CTAB (now officially known as cetrimide) has been used extensively in this hospital and in the numerous large factories in this area, both for the initial treatment of wounds and also during their subsequent redressing. We wish to record the occurrence of further cases of skin reaction to CTAB. In these cases the skin reaction caused considerable disability although in most instances the initial injury was trivial. In all, fourteen cases have been encountered since 1946. Typical case histories are quoted below.

Case Reports

Case 1.—A man, aged 44, employed as a maintenance worker, sustained a scalp wound while at work, and it was dressed at the factory surgery with acriflavine after preliminary cleansing with cetrimide. The wound did not heal and, after a fortnight's treatment with repeated dressings and cleansings at the factory, he was referred to the Accident Hospital, where again cetrimide was applied as a cleansing agent. When cetrimide was applied once more a week after he was first treated at this hospital, the patient developed a red, irritating dermatitis on the scalp round the injury. There also appeared a red streak running from this area of dermatitis across the temporal region down the cheek to the angle of the mouth and ending in a group of vesicles (fig. 1). The presence of this red streak, conforming to no anatomical structure, appeared to be due to the application of an irritating substance. No further cetrimide was applied, and the erythema and vesiculation subsided and the wound healed within a week. Subsequent patch tests showed a strong vesicular reaction to 0·1 per cent. cetrimide.

Case 2.—A man, aged 32 years, employed as a die-caster, stated that he frequently sustained minor burns in the course of his work. If he treated the burns at home they healed well but if he had them treated at the factory surgery he got a rash round the burned area.

On this occasion, the patient had multiple small metal splash burns on the arm and back which were treated with 1 per cent. cetrimide and penicillin cream. Two days later he reported because of a rash which had developed on the areas cleaned with cetrimide. The rash consisted of multiple small vesicles with an underlying erythema. No more cetrimide was applied, the dressing of penicillin cream was continued, and both burns and dermatitis were healed in two weeks.

Case 3.—A man, aged 47, employed as a sheet metal worker, had a previous history of dermatitis following a burn which had been treated with Glasgow No. 9 (and probably cetrimide also) in 1946. Two previous burns treated in the same way had healed normally.

On this occasion he cut his left forearm while at work, and the wound was cleansed with cetrimide before suture. When the dressings were removed five days later he had a dermatitis over a rectangular area surrounding the cut. This dermatitis was pustular in nature and swabs yielded *Staph. aureus* (coagulase-positive). The condition had almost healed when, three weeks later, cetrimide was inadvertently applied to the arm. This produced an acute vesicular irritating eruption over the whole forearm, and one week later a secondary rash appeared on the face and calves—this latter site corresponding with an area of friction from Wellington boots which he had been wearing. This vesicular dermatitis became secondarily infected with *Staph. aureus*, and admission to hospital for five days was necessary. The patch test reaction to 1 per cent. cetrimide was violent, and in addition a mild reaction to sulphanilamide occurred.

This patient returned to our care on three further occasions, twice because of the application of cetrimide and once because he had been given sulphonamides by mouth.

During his first attack he lost twelve weeks' working time.

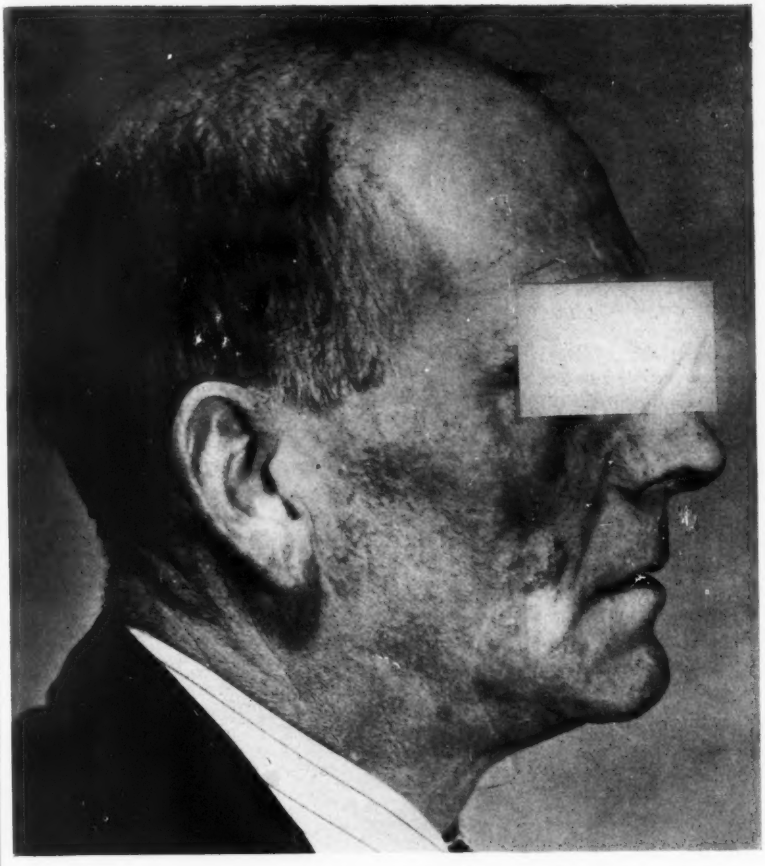

FIG. 1.—Skin sensitivity to cetrimide: erythematous reaction on scalp; red line running down side of face and ending in a group of vesicles.

FIG. 2.—Severe patch test reaction to 1 per cent. cetrimide, photographed ten days after application.

Clinical Findings

Diagnosis.—The clinical appearances of the skin reaction to cetrimide conform to those of any chemical sensitization reaction. The history of previous applications, with or without reaction, and an irritating vesicular dermatitis corresponding with the area of application, provide strong circumstantial evidence of the agent responsible. The main difficulty in detecting the cause of the rash in our patients had been the initial failure to recognize cetrimide as a possible sensitizing agent. In some cases in which early secondary infection has occurred the appearances may be confused with those of an infective dermatitis surrounding a septic abrasion. On occasion the local reaction is accompanied by a generalized vesicular dermatitis affecting areas of skin to which cetrimide has not been applied. Characteristically the areas affected by the secondary reaction are those exposed to friction. This "disseminated reaction" is especially liable to occur when the nature of the local rash is not recognized and the application of cetrimide is continued.

Patch Tests.—The diagnosis can always be confirmed by the patch test. This was performed on all of our patients—each patient being tested with all the likely agents to which he had been exposed. This usually included penicillin, sulphonamides, flavine, lanette wax, cetrimide, and sometimes adhesive plaster. A control patch of saline was used.

A fine scratch was made in the horny layer insufficiently deep to draw blood. Over this scratch was placed a square of lint soaked in the appropriate chemical. This lint was held in place with a piece of lint 2 inches square coated with melted Unna's paste. All the patches were secured by a bandage. The dressings were removed in twenty-four hours and further observed after forty-eight hours. It was found that in sensitized patients 1 per cent. cetrimide (the strength previously recommended for use) produced a very severe reaction (fig. 2), and consequently 0·1 per cent. solution was used in later cases. The 0·1 per cent. solution produced in the sensitive patient severe itching in eight or ten hours; by twenty-four hours the site of the patch was raised and reddened, and by forty-eight hours a crop of very fine superficial vesicles appeared. The reaction then faded in a few days more. Many other patients tested in this way gave no reaction to cetrimide, and consequently the response cannot be one of simple irritation.

Eosinophilia.—Since in our experience eosinophilia frequently accompanies skin sensitivity reactions, a study was made of the blood eosinophil counts of these patients. The technique used was the direct count described by Discombe (1946).

Those patients (three in number) who developed a secondary vesiculation on sites to which cetrimide had not been applied had high eosinophil counts (738 to 869 per c.mm. of blood), but those in which the vesiculation was confined to the original area of application showed no eosinophilia. Two patients who had cetrimide applied to an extensive area of skin had eosinophil counts of 425 to 456 per c.mm. of blood. Since the upper limit of normality for the eosinophil count is indefinite (conventionally taken as 320 per c.mm.), the interpretation of these last two results may be left open. In those patients who developed eosinophilia the maximum levels were reached on the eighth to tenth days after the application causing the skin reaction.

Thus the value of eosinophilia as an aid to the diagnosis of cetrimide sensitivity appears to be limited.

Sensitizing Applications and Duration of Sensitivity.—Although an accurate history was not always obtainable it appeared fairly certain that several applications of cetrimide were necessary before sensitization was induced. Most cases gave a clear history of previous applications of cetrimide without ill effect.

Patients patch tested eighteen months after their initial dermatitis gave positive results and so it is obvious that, once induced, the sensitivity is of long standing. Three of our patients had further reactions when cetrimide was inadvertently applied to their skins for subsequent injuries.

Duration of Disability.—With the exception of Case 3 who lost twelve weeks' working time, the usual duration of disability was two or three weeks. Thus of itself the condition is not very serious. But not infrequently the injury necessitating the use of cetrimide was trivial and would not ordinarily have resulted in any lost time. The need to recognize the true nature of the reaction is made greater by the tendency for factory workers to sustain repeated injuries, and consequently to have repeated applications of cetrimide in the factory surgery.

Experiments Designed to Determine the Sensitizing Chemical in Cetrimide

Since cetrimide is a complex mixture of chemicals, and since the formula of pure cetyl trimethyl ammonium bromide shows no relationship with that of other notorious sensitizing substances, the possibility that a contaminating chemical was

responsible for the reaction was investigated. Attempts to sensitize albino guinea-pigs by surface application and intradermal injection of the compound failed, and consequently we had to rely upon sensitized patients to volunteer for further patch tests. This reduced the number of observations that could be made.

A series of negative results with patch tests with potassium bromide indicated that sensitivity to the bromine ion was not the cause of the reaction. Three patients tested with cetyl trimethyl ammonium chloride produced positive patches. This further suggested that either the long-chain radicle or a contaminating chemical was the responsible agent. Accordingly a specially prepared sample of cetrimide was used to test three more patients. This " pure " cetrimide caused reactions equivalent to the impure product. Treatment with alkali (to eliminate organically bound bromine) also failed to destroy the chemical responsible for the reaction. Finally three patients sensitive to cetrimide failed to react to trimethylamine, a possible contaminant of cetrimide which has been recognized as a cause of dermatitis (Horner, 1934).

Thus these investigations were negative. Theoretically it is conceivable that the patients were initially sensitized by a chemical allied to cetrimide and that subsequently the reaction was elicited also by the " pure " compound. But on the other hand a clinical estimate of the severity of the skin responses to the " pure " and the commercial product suggested no difference in response. Although from a scientific point of view this problem has not yet been finally answered, for practical purposes it would appear that cetrimide, as produced commercially, is the agent responsible for the reaction.

Discussion

Although fourteen cases of skin sensitivity reaction to cetrimide have been observed, no further information as to the incidence of this condition can be derived from these figures. Since minor abrasions and burns are frequent in industry, and since cetrimide is used so extensively, it seems likely that the incidence figure of 1·5 per 1,000 reported by Colebrook is not an excessive estimate. But on the other hand where certain workers are repeatedly exposed to minor burns, for example, in die-casting, and consequently are subjected to repeated applications of cetrimide, the chances of inducing sensitivity reactions are increased. Among all the patients in whom we have diagnosed dressing sensitivity, cetrimide was the most frequent single cause. This may simply reflect the widespread use of this compound, which is often regarded as quite innocuous.

Since the skin reaction may on occasion be severe, it appears to be wise to use cetrimide only for the primary cleansing of wounds. By eliminating multiple applications at subsequent re-dressings the chances of inducing sensitivity are reduced. Cetrimide is sometimes used as a skin antiseptic before penicillin injections. This again involves repeated application, and should be discouraged.

However, since cetrimide has many advantages as a wound cleanser it would seem neither desirable nor necessary to discontinue its use, so long as these precautions are observed. Clearly no cetrimide should be applied to patients who have already exhibited sensitivity rashes from its use.

Summary

1. Skin reactions in fourteen patients caused by the application of cetrimide (CTAB) are reported. The clinical findings and the results of patch tests are described. The rashes are due to skin sensitization.

2. Eosinophilia was found to accompany several of these rashes, particularly when they were extensive or involved body areas remote from the original application of cetrimide.

3. Attempts to find a pure form of cetrimide which did not elicit skin reactions in sensitized patients have failed.

4. Practical recommendations have been made on the basis of these findings.

We wish to acknowledge the assistance given to us by Messrs. Imperial Chemical (Pharmaceuticals) Ltd., particularly by supplying samples of the components of Cetavlon and by making a laboratory preparation of highly purified Cetavlon. We are also indebted to Dr. C. R. Ricketts for his assistance with the preparation of various modifications of cetrimide. We are grateful to our surgical colleagues of the Birmingham Accident Hospital and to numerous industrial medical officers in this area for kindly referring to us their cases of dressing sensitivity.

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THE PROBLEM OF CONSISTENT RADIOLOGICAL DIAGNOSIS IN COALMINERS' PNEUMOCONIOSIS

AN EXPERIMENTAL STUDY

BY

C. M. FLETCHER and P. D. OLDHAM

From the Pneumoconiosis Research Unit of the Medical Research Council

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Introduction

The classification of cases of pneumoconiosis according to their severity is often necessary. In the practical field it is essential in the assessment of cases applying for compensation for industrial lung diseases, and in deciding whether to recommend suspension from employment in dusty environments. In research it is necessary for such purposes as the study of the progression of the disease and of its varying incidence in different environmental conditions. Since a chest radiograph provides the only sure method of diagnosing pneumoconiosis in life, and since no simple method for the objective assessment of respiratory disability is available, most schemes of classification have been based primarily upon the radiological picture. (For an account of the literature see Hart and Aslett, 1942.)

In view of the great practical importance of the problem, it is surprising that little attention has been given to the difficulties inherent in the accurate classification of chest radiographs in pneumoconiosis. It has been shown that in the radiological diagnosis of the presence of pulmonary fibrosis (Herbert, 1939) and of pulmonary tuberculosis (Birkelo and others, 1947) great disparities exist between the opinions of different trained observers and that their opinions are not always self-consistent, and it has also been shown that in the clinical assessment of malnutrition (Derryberry, 1938 ; Huws Jones, 1938) and of cyanosis (Comroe and Botelho, 1947), and even in the instrumental assessment of hæmoglobin concentrations (Macfarlane, 1945), similar disparities of opinion arise. It seemed desirable to investigate the reliability and precision which it is possible for experienced observers to achieve in the classification of chest radiographs in pneumoconiosis.

This information was particularly needed for an investigation undertaken by the Pneumoconiosis Research Unit of the Medical Research Council into the progression of coalminers who had been radiographed by Hart and Aslett (1942) between 1938 and 1940 and who had continued to work underground for some years after. Some of these men were radiographed again in 1946 and the radiological progression of their pneumoconiosis was assessed in relation to the dust exposure that they had undergone in the interval. This radiological assessment demanded the classification both of the original Hart and Aslett films and of the more recent films taken by the Pneumoconiosis Research Unit. It was important to find out how accurately this was being done and whether the classification employed corresponded to that employed by the Silicosis Medical Boards.

Description of Experiment

An experiment in *x*-ray classification was designed with the intention of answering these questions. A set of films was chosen from those used by Hart and Aslett, the Pneumoconiosis Research Unit, and the Silicosis Medical Boards, representing the early stages of pneumoconiosis (in which the greatest difficulties of accurate diagnosis arise). These films were classified into five categories of increasing abnormality by ten observers of varying experience of pneumoconiosis, so that the effect of experience on what should be a purely objective diagnosis would be apparent. To assess the consistency of the classification given to the films, each observer read them a second time in a different order without being told what his previous classifications were.

The films were chosen so that certain other questions could be answered by the experiment. The level of the radiographic abnormality necessary before a Silicosis Board can certify a case is not defined in the Coalminer's Pneumoconiosis Scheme of 1943, so the Silicosis Medical Boards have had to determine for themselves the level of abnormality which should be considered "certifiable." This level of abnormality was within the range covered by the chosen films, and thus evidence of the way in which the definition of "certifiability" was interpreted in practice, and the consistency of the interpretation, could be obtained from the results. A group of films was also included which would show the effect of different radiographic techniques on classification. The experiment was also intended to suggest the answers to certain other questions.

The Observers.—Throughout this paper the ten observers will be referred to by the capital letters A to K (omitting I). Their differing experience of films of pneumoconiosis is indicated by the following brief notes.

A and B.—Members of the medical staff of the Pneumoconiosis Research Unit who were engaged on the classification of the films of the Hart and Aslett Survey and its follow up.

C and D.—Members of the medical staff of the Pneumoconiosis Research Unit with scientific training but with less experience in the interpretation of radiographs of early pneumoconiosis.

E and F.—Senior members of the Silicosis Medical Boards. They had long experience in the classification of films as "certifiable" and "not certifiable," but less experience in the finer classification of films that were "not certifiable."

G.—A junior member of the Silicosis Medical Boards who had spent several months working with the Pneumoconiosis Research Unit in the classification of the Hart and Aslett films referred to above. He combined, for shorter periods, the experience of observers A and B, and E and F.

H.—A tuberculosis physician who had taken part in the classification of the films of the Hart and Aslett Survey in 1940. He had continued to work in a South Wales mining area and so had continued to see many cases of coalminers' pneumoconiosis.

J.—A tuberculosis physician who had taken part in the original classifications of Hart and Aslett's films in 1940 but who had, for the past five years, seen little of coalminers' pneumoconiosis.

K.—A tuberculosis physician who had worked for several years as a Mines Medical Officer and was engaged upon a study of early pneumoconiosis in working miners.

It was suggested that the lack of agreement and consistency that were discovered might be attributable to the fact that none of the observers was a trained radiologist. The two consultant radiologists on the staff of London teaching hospitals, who had special knowledge of chest diseases in general were, therefore, asked to read the films, and they agreed to do this. They are referred to respectively as observers L and M. Since the main investigation was intended to explore opinions of doctors concerned primarily with coalminers' pneumoconiosis, and since the opinions of observers L and M were not included when the standard categories referred to below were determined, their opinions are considered separately, and are included in the tables in this paper in brackets and in the figures in dotted lines. Observer M would only use categories 1, 2, 4, and 5, so that it is not possible to calculate some of the indices from his readings.

Reading of Films.—The films were arranged at random (by drawing their reference numbers out of a hat) and each was given a serial number. Each observer read them in order 1 to 102 on the first occasion and in the reverse order (102 to 1) on the second. He was given his own choice of viewing screen.* He was asked to classify each film into one of the following categories: (1) within normal limits; (2) very early pneumoconiosis; (3) definite pneumoconiosis, but not certifiable for purposes of compensation; (4) definite pneumoconiosis of certifiable degree but showing only "reticulation"; (5) more than "reticulation," that is, "nodulation" or "coalescent shadows."

These categories were later used as a basis for the formal classification of simple pneumoconiosis published by Davies and Mann (1948). The numbers used by Davies and Mann, however, are different. They use the figure 0 to indicate normal films, so that their category 1 is roughly equivalent to our category 2, their category 2 to our category 3, and so on.

Before the films were read, the categories were discussed and, if necessary, elaborated or explained

* All observers except E and J used a General Electric *X*-ray Corporation Fluoroline illuminator. E and J used a Kodak illuminator.

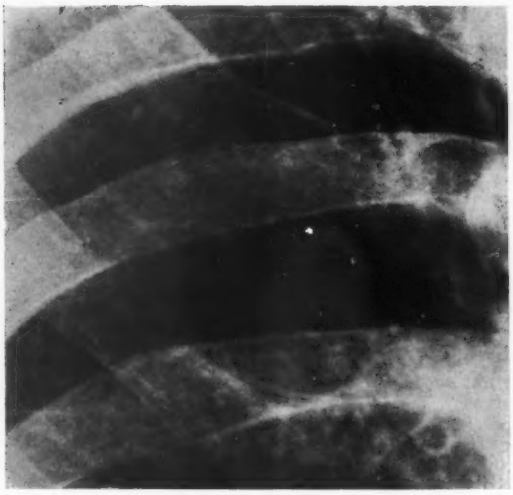

FIG. 1.—Stage 2.
Average opinion 1·9. Standard opinion 2.

Category	1	2	3
No. of opinions ..	7	8	5

Davies and Mann (1948) category 1.

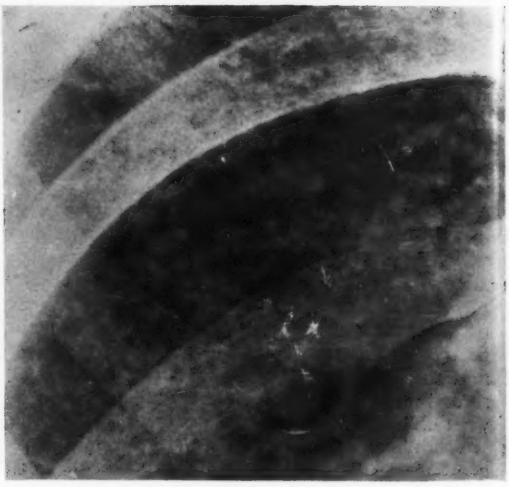

FIG. 2.—Stage 3.
Average opinion 3·0. Standard opinion 3.

Category	2	3	4
No. of opinions ..	4	12	4

Davies and Mann (1948) category 2.

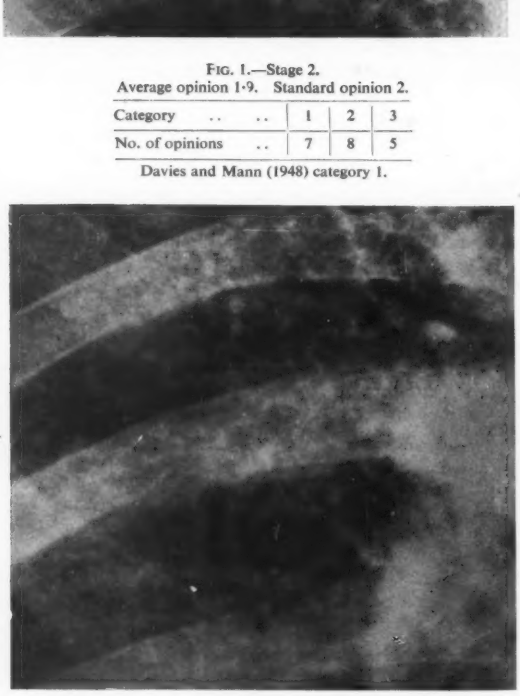

FIG. 3.—Stage 4.
Average opinion 4·0. Standard opinion 4.

Category	3	4	5
No. of opinions ..	2	16	2

Davies and Mann (1948) category 3.

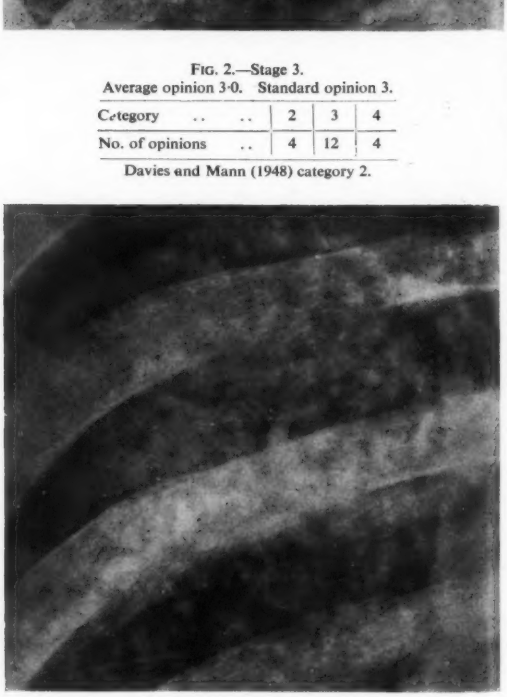

FIG. 4.—Stage 5 (nodulation)
Average opinion 4·25. Standard opinion 4.

Category	4	5
No. of opinions ..	15	5

Davies and Mann (1948) category 4.

FIGS. 1 to 4.—Photographs of the right mid-zone of typical examples of stages 2, 3, 4, and 5. It should be noted that these are respectively examples of categories 1, 2, 3, and 4 according to the classification of simple pneumoconiosis published by Davies and Mann (1948). Under each photograph is given the average opinion of all observers on the film, the standard opinion, and the number of opinions of each category given to the film in the course of the experiment. These are all Victor Medium Films.

by the authors. After the reading of the films had started there was no further discussion or comment on any of the diagnoses, except that the observer was invited to comment on the radiographic technique of any film if it disturbed his judgment. He was also told the age of each case whose film was under consideration if he asked for it. Names and identification numbers on the films were obscured by a mask.

Observers A, B, C, D, G, H, J, K, and M read the films alone. Observers E, F, and L read them with colleagues who occasionally disagreed with their opinion, but the opinion of the observer under test was taken in every such case.

The interval between the two readings of the films by each observer was as follows : observers A, B, C, F, G, 1 week ; observers D, E, H, K, 2 weeks ; observer J, 5 weeks.

Selection of Films.—Films chosen from three sources were given a preliminary classification by the authors in order to ensure fair representation of the particular degrees of abnormality whose diagnosis we wished to investigate. This preliminary classification was used for reference purposes only ; later it will be shown how a " standard category " was determined for each film from the experimental results. To make the distinction clearer the word " stage " will be used whenever the preliminary classification is referred to, the word " category " when a classification made during the experiment is described. For example, three stage 2 films might subsequently be given standard categories of 2, 2, and 3 when the experimental results were examined.

Photographs of the right mid-zone of typical examples of stages 2, 3, 4, and 5 are reproduced (figs. 1 to 4).

SOURCE (A) VICTOR FILMS

Set used : Victor 4-valve Photo-Rœntgen Unit with Coolidge Rotating Anode Tube.
Anode-Film distance : 6 feet.
Focal Spot : 2 mm.
Anode Current : 400 mA.
Peak Voltage : 55–58 kV (according to chest thickness).
Film : Kodak code 6, with High Definition Intensifying Screens.
Exposure Time : (average) 0·1 sec.
Processing : Kodak Blue Label Developer, for five minutes at 65° F. Intermediate rinsing and fixing for at least twenty minutes, followed by prolonged washing in running water.
Comment : Films were taken in 1946. They were a little more penetrated than is usual for chest work, the spine but not the intervertebral discs being just visible through the cardiac shadow.

Films were chosen from cases that had been examined by Hart and Aslett in 1938 and were considered to have shown no radiological progression between then and their recent examination in 1946, when the two films from each case were compared side by side, and whose recent (Victor) films appeared to fall into the stages 1 to 4 defined above. Ten examples were taken in each stage. From these forty " Victor " films, examples of each stage were chosen which appeared on juxtaposition to form a series of equal graduations from 1 to 4. These were taken as reference films. In each stage those films which most closely resembled the reference films were selected in order to form groups of films within the four stages. The other films were rejected. In this way, four stage 1, six stage 2, six stage 3, and six stage 4 films were selected. Four cases of nodulation and four with early coalescent or early " ambiguous " (Davies and Mann, 1948) shadows on a background of reticulation were also selected. This set of films will be referred to as " Victor Medium" films.

There existed for nine of the cases included among the Victor Medium films (three each of stages 2, 3, and 4) additional films of greater and less penetration, taken on the same day. The over-penetrated films will be called " Victor Hard " films and the under-penetrated films " Victor Soft " films. These nine triple-film cases provided an opportunity for estimating the effect of technique on the categories of the films, as will be seen later.

SOURCE (B) " H AND A " FILMS

Set used : Coolidge 10 kW.
Anode-film distance : 4 feet 6 inches.
Focal spot : 3·8 mm.
Anode current : 100 mA.
Peak voltage : 60–70 kV (according to chest thickness).
Film : Ilford, with Fluorazene screens.
Exposure time : 0·1 sec.
Comment : The films were taken between 1938 and 1940 by Messrs. Portable *X*-Rays.

The films were selected from the same cases as the thirty Victor Medium films. Since they were all cases in which no progression was apparent in the interval between the films, they were assumed to be in the same disease-stages, although it was found later that this assumption was not confirmed by the observer's opinions in the course of the experiment (see Table 11).

SOURCE (C) " SI.B." FILMS

Dr. N. Keating of the Cardiff Silicosis Medical Board allowed us to select twenty-four films from the patients examined by his Panel during 1946, half of whom had been rejected and half of whom had been certified. From these, twelve certified and twelve rejected cases were chosen which were considered after comparison with the standard reference films to fall into stages 3 and 4. Unfortunately, it was later found that by a clerical error thirteen rejected cases and eleven certified cases had been chosen. These films are referred to respectively as " Si.B.R." and " Si.B.C." films.

Set used : Watson 4-valve.
Anode-film distance : 5 feet.
Focal spot : 1 mm.
Anode Current : 300 mA.

Peak Voltage : 45–70 kV (according to chest thickness).

Film : Kodak Blue Brand with Kodak fast screens.

Exposure time : 0·08 sec.

Comment : The films were taken in 1946 by a private radiologist.

Thus the final set of 102 films selected for the experiment was made up as follows :

Victor Medium : 4 stage 1, 6 stage 2, 6 stage 3, 6 stage 4, 8 stage 5, Total : 30.

Victor Soft : 3 stage 2, 3 stage 3, 3 stage 4, Total : 9.

Victor Hard : 3 stage 2, 3 stage 3, 3 stage 4, Total : 9.

H and A : 4 stage 1, 6 stage 2, 6 stage 3, 6 stage 4, 8 stage 5, Total : 30.

Si.B.R. : 9 stage 3, 4 stage 4, Total : 13.

Si.B.C. : 3 stage 3, 8 stage 4, Total : 11.

All Groups : 8 stage 1, 18 stage 2, 30 stage 3, 30 stage 4, 16 stage 5, Total : 102.

The distribution of standard categories (based on the results of our experiment) within the various groups of films will be found in Table 11.

During the course of the trial, some observers objected to certain films on technical grounds, considering them to be unreadable. In certain of the calculations these films were excluded, but in no case did such exclusion have any significant effect on the results.

Results

Part I. Lack of Agreement

Discrepancies of Opinion.—With the exception of C and D the ten observers were all experienced in the radiological diagnosis of early coalminers' pneumoconiosis, and with the exception of J they were engaged in the scrutiny of such films every day in South Wales. Their opinions might thus be expected to be fairly uniform. In fact there was a remarkable disparity between the twenty opinions given on each film. This disparity may be expressed as in Table I by stating the range of extreme opinions expressed. There were three films on which the opinions expressed covered the whole range of four categories, being considered normal by one observer, while another considered them as examples of " more than reticulation." (In each of these films the diagnosis of category 5 was based on the supposed presence of an area of coalescent shadowing in some part of the film ; they were not diagnosed as examples of " nodulation." In each of them, however, there were one or more diagnoses of category 4.) There were in addition thirty films, just under one third of the total, in which there was a range of three categories in extreme opinion—from " normal " to " certifiable reticulation " or from " very early pneumoconiosis " to " more than reticulation."

TABLE 1

RANGE OF EXTREME OPINIONS OF OBSERVERS A–K

Range of one category		Range of two categories		Range of three categories		Range of four categories	
Extreme opinions	No. of films	Extreme opinions	No. of films	Extreme opinions	No. of films	Extreme opinions	No. of films
1–2	5	1–3	18	1–4	16	1–5	3
2–3	1	2–4	21	2–5	14	—	—
3–4	4	3–5	15	—	—	—	—
4–5	5	—	—	—	—	—	—
Total	15	Total	54	Total	30	Total	3

When the films which any observer had considered unreadable were removed from the group, the results were not much altered. Only one of the films with a range of opinion of 4 categories and one with a range of 3 categories fell in the " unreadable " class.

When the opinions on all the films of observers L and M are considered, we find there were fourteen films diagnosed by L as category 4, but diagnosed by M as category 1 ; ten films which L diagnosed as category 5 but which M diagnosed as category 2, giving twenty-four films in which the opinions of these two observers differed by three categories. There were in addition, four films which observer L diagnosed as category 5 and M diagnosed as category 1. It is thus apparent that the disparity of opinion between these two consultant radiologists is at least as great as that between the ten other observers.

Perhaps the most remarkable feature of the disparity of opinion shown by this trial is the disagreement revealed as to the limits of normality. Including the opinions of L and M together with the other ten observers, we find that of the 56 films considered " normal " on at least one occasion :

5 were considered on at least one other occasion to be in category 2

17 were considered on at least one other occasion to be in category 3

21 were considered on at least one other occasion to be in category 4

11 were considered on at least one other occasion to be in category 5

The question of determining the limits of normality is of great importance in investigations of the incidence of pneumoconiosis in various industries or in different factories or mines within a given industry. In Table 2 are given the numbers of films placed by each observer in category 1 (normal) on either test, the first test, the second test, and on both tests. It will be seen that if these observers had undertaken independent surveys to determine the

incidence of pneumoconiosis among some group of workmen, their conclusions on the incidence of disease would be very different.

Inconsistency of Observers.—It will have already been noted in Table 2 that each observer did not give the same opinion on the films on the two occasions on which he saw them. One would not expect to find that the inconsistencies between the two readings of the film given by each observer would be as great as the disparities that were found in the twenty readings of the films given by all ten observers. Table 3 shows for each observer the number of films which he placed in the same category on the two readings, and the number of films in which his opinion differed by 1, 2, or 3 categories on the two occasions. It will be seen that all the observers placed at least half the films in the same category on two occasions, and a change of

TABLE 2

THE NUMBER OF NORMAL FILMS ACCORDING TO EACH OBSERVER

Observer	Number of films called normal on :			
	First test	Second test	Either test	Both tests
A	5	7	7	5
B	5	8	9	4
C	5	6	8	5
D	3	4	4	2
E	14	13	18	9
F	11	8	12	7
G	10	5	10	5
H	17	11	18	9
J	21	20	25	14
K	29	21	30	20
(L)	(10)	(10)	(13)	(7)
(M)	(44)	(42)	(52)	(34)

three categories (categories 2 to 5) occurred only once. In this table the changes of opinion in either direction are considered together. The question of general trends in the differences of opinion between the observers and in the two opinions of observers on two occasions will be considered later.

Average Opinion.—In the course of analysing our results, we shall have occasion to consider groups of film-classifications, the characteristics of which can most easily be described by the use of averages. The different averages we shall use are defined as follows :

(a) *The average opinion of any observer on a particular group of films* is the arithmetic mean of the category-numbers which he allocated to each film in the group.

(b) *The average opinion of a group of observers on any given film* is the arithmetic mean of all the category-numbers allocated by the observers to this film.

(c) *The average opinion of an observer on any one film* is the arithmetic mean of the two category-numbers allocated by him to the film on the two occasions on which he saw it.

Effect of Radiographic Technique on Categorization.—To provide evidence on the effect of radiographic technique on the classification of films we have available the nine cases of each of which three films were taken on the same day with medium penetration, over-penetration and under-penetration. The effect of technique on opinion may be analysed in two ways.

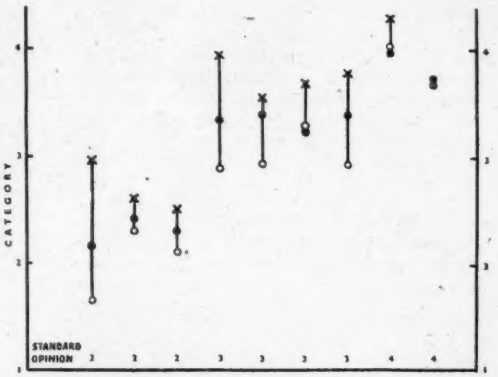

FIG. 5.—Diagram showing effect of radiographic technique on the average opinion of all observers on the twenty-seven films from the nine cases, each of whom had three films taken on the same day with low penetration ("soft" films), medium penetration, and high penetration ("hard" films). The mean opinion of all observers on the three films of each case are plotted on the same vertical line. The vertical axis is marked in category numbers.

× Mean opinion on "soft" films (low penetration).

● Mean opinion on "medium" films.

○ Mean opinion on "hard" films (high penetration).

First we can consider the effect of the "average opinion of all observers" on each of these twenty-seven films. In fig. 5 the average opinion of all the observers on each of the three films of each case is plotted against an axis marked in category-numbers. The average opinions on the three films taken of each case are plotted on the same vertical line. It will be seen that, except for Case 9, the soft (under-exposed) film is in each case rated higher than the medium and hard (over-exposed) films, and

except for Cases 6, 8, and 9 the medium film is rated higher than the hard film.

It will also be noted that the effect of technique on the average opinion is not the same in each of the cases. This may be because unfortunately the degree of over- and under-penetration was not the same in the corresponding films in this group, so that the differences between hard, medium, and soft were not always of the same order. To provide some absolute measure of differences in technique within each set of three films, densitometer readings were taken in the third right anterior rib space of each film, and the average change of opinion with change of technique was plotted against the corresponding differences of optical density, but only a very rough linear relation between the two was apparent. In particular there were six points which diverged widely from the others. Those derived from Case 9 may be explained by the fact that the films of this case were of a characteristic generalized pin-head type (Davies and Mann, 1948) in which the diagnosis of certifiable reticulation was reached easily by nearly all the observers and the differences in technique were insufficient to obscure the pattern. No explanation could be suggested for the other divergent points. Thus, while optical density is one factor which results in changes of opinion with changes in radiographic technique, other factors are probably involved.

The effect of technique on the opinions of the individual observers can also be examined. In fig. 6, the "average opinion of each observer" on all the nine hard, nine medium, and nine soft films are plotted on the same vertical lines. It will be seen that some observers (for example C, E, F, and J) are seriously affected by technical differences in the expected direction, but others (for example A, B, and G) are only slightly affected. Observers B, D, and G either compensate completely for over-penetration or even over-compensate so that a lower mean opinion is given by them for the medium than for the hard film. Observers H and M over-compensated for under-penetration.

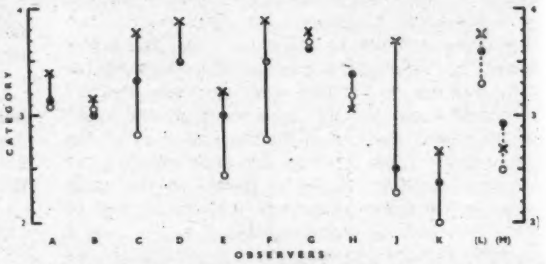

FIG. 6.—Diagram showing the effect of radiographic technique on the average opinion of each individual observer on the twenty-seven films from the nine cases each of whom had three films taken on the same day with low penetration ("soft" films), medium penetration, and high penetration ("hard" films). The average opinion of each observer on all nine "hard" films (over-penetrated) of all nine medium films and all nine "soft" films (under-penetrated) is given on the same vertical line. The vertical axis is marked in category numbers.

× Mean opinion of each observer on "soft" film (low penetration).

● Mean opinion of each observer on "medium" film.

○ Mean opinion of each observer on "hard" film (high penetration).

TABLE 3

CHANGES OF OPINION BETWEEN FIRST AND SECOND READINGS

Observer	Number of films in which difference between first and second opinions was :			
	Nil	One category	Two categories	Three categories
A	75	27	—	—
B	84	18	—	—
C	55	46	1	—
D	66	32	4	—
E	64	37	1	—
F	70	30	2	—
G	62	33	7	—
H	59	40	3	—
J	54	37	10	1
K	58	40	4	—
(L)	(59)	(35)	(8)	(—)

Certification.—For the purposes of reaching decisions concerning compensation for pneumoconiosis, the Silicosis Medical Boards are not required at present (early 1948) to classify films into several stages. They are only required to place the films above or below a certain standard of abnormality. This standard has never been defined but it is based on the description of reticulation given by Hart and Aslett (1942, p. 48). "The lung fields show a fine network, sometimes sharp and lace-like in pattern, but much more often blurred in appearance. The network occupies from half of one lung field to (more frequently) the whole of both fields, though the apices are relatively free. It is as marked at the periphery of the fields as it is nearer the hila." This definition is only partly quantitative and it would not be surprising, in view of the disparities and inconsistencies of opinion which we have already described, to find different observers interpreting it in different ways. Since categories 4 and 5 in our experiment were defined respectively as "certifiable reticulation" and "more than certifiable reticula-

TABLE 4

NUMBER OF FILMS CONSIDERED "CERTIFIABLE" BY EACH OBSERVER

Observer	Number of films "certified" on:				Consistency of certification (%)
	First test	Second test	Either test	Both tests	
A	41	32	44	29	66
B	29	27	30	26	87
C	45	40	55	30	55
D	52	53	63	42	67
E	34	34	36	31	86
F	50	53	58	45	78
G	41	51	55	37	67
H	38	47	49	36	73
J	32	35	41	26	63
K	12	9	16	5	31
(L)	(54)	(58)	(65)	(47)	(72)
(M)	(36)	(34)	(40)	(30)	(75)

tion," it is possible to use our results to examine the question of errors in certification; for all films placed in categories 4 and 5 by any observer must have been regarded by him as showing sufficient abnormality for certification. Table 4 tabulates the results from this point of view. It shows the number of films "certified" by each observer on the first, second, or both tests. It will be seen that there are great differences between the observers. Observer D, for instance, "certified" 63 films on at least one occasion whilst observer K "certified" only 16, and observer F, of the Silicosis Medical Board, "certified" 50 per cent. more cases than his colleague E. There are also considerable inconsistencies in this matter of certification between the two opinions given by each observer, although here too, the inconsistencies between the observer's two opinions are less marked than the disparities between the various observers.

There is another factor that will greatly affect an applicant's chance of certification. This is the radiological technique of the film with which he applies. The effect of technique on certification is shown in Table 5, which gives the number of certifying opinions (out of twenty given) on each of the twenty-seven films of the nine cases who had a hard, medium, and soft film taken on the same day. The effect of technique is striking, especially in the cases in standard category 3 near the border-line of certification. Had Case IV, for instance, applied to a panel made up of the observers in the experiment, he would have had a fourfold greater chance of certification if he had applied with his soft film than if he had applied with his hard film.

These results show how greatly the chance of certification of any applicant to the Silicosis Medical Board may depend upon the particular doctor who assesses his film and even on changes in this particular doctor's opinion from day to day, and they reveal the need for some degree of assessment which will lead to more consistent results.

The films in this trial, however, were deliberately chosen to include a large number in the earlier stages of the disease. There would clearly be very much less or even no inconsistency in the certification of cases with completely normal films or with films showing massive shadows. It is, therefore, of importance to examine the relevance of our results to the present practice (1948) of the Silicosis Medical Board. A review was made of four hundred films of men applying to the Silicosis Medical Boards at Cardiff and Swansea during the first six months of 1948, for the purpose of estimating in what proportion of them conflict of opinion concerning certification might arise.

Two films were selected from the experimental group of 102, which (from the average opinion of the ten observers), appeared to mark the boundaries of the range of abnormality in which "certifiability" could be disputed. (One film had the lowest average opinion of those on which there was only one *certifying* opinion given by observers E and F, members of the Silicosis Boards; the other had the highest average opinion of those on which only one *non-certifying* opinion was given by E or F). The four hundred films were then

TABLE 5

NUMBERS OF "CERTIFYING" OPINIONS (CATEGORIES 4 OR 5) ON NINE CASES WITH HARD, MEDIUM, AND SOFT FILMS TAKEN ON THE SAME DAY

—	Standard category	2			3				4		Whole group
	Case No.	I	II	III	IV	V	VI	VII	VIII	IX	
No. of "certifying" opinions when technique was:	Hard	—	—	1	4	4	8	5	17	15	54
	Medium	—	—	1	9	9	6	7	18	16	66
	Soft	—	5	1	16	11	14	11	19	14	91

divided into those that lay below, between, or above these two standards in degree of abnormality, assessed by side-by-side comparison. It will be suggested later that this comparative technique is inherently more accurate than the assessment *in vacuo* used during the trial and in general radiological practice.

The results of this review are shown in Table 6. During this period, 20 per cent. of cases applying to the Cardiff Panel and 24 per cent. applying to the Swansea Panel fell into the disputable class that might be certified by E or F, of the Silicosis Medical Boards, on one day, but rejected on another, or certified by one but rejected by the other on the same day. This review suggests that variability of opinion on certification is a matter of considerable importance in the present work of the Silicosis Medical Boards.

TABLE 6

THE PROPORTION OF "DIFFICULT" FILMS FOUND IN PRACTICE

Sample of 200 films from Silicosis Boards at :	Level of abnormality in relation to standard films		
	No. below	No. between	No. above
Cardiff : first 95 films ..	61	19	15
second 105 films	52	21	32
Total	113 (57%)	40 (20%)	47 (24%)
Swansea : first 100 films..	43	25	32
second 100 films	39	23	38
Total	82 (41%)	48 (24%)	70 (35%)

The question, "Is this film certifiable?" is often asked. It is evident from our finding that, with the present methods of assessment of films, this question can only be answered confidently in cases with obviously normal or grossly abnormal films. In films with intermediate degrees of abnormality, such as those which we selected for our experiment from the Silicosis Medical Board, the decision can only be given with limited confidence. A measure of this confidence for each film is provided by the proportion of our ten observers who gave a certifying opinion upon it. Table 7 shows, for the Silicosis Board films, the number and percentage of the twenty opinions given on each film by our ten observers that were "certifying" opinions (that is, opinions of category 4 or 5). The average percentage (44 per cent.) of those films that had, in fact, been certified is higher than that (22 per cent.) of those that had not been certified, but there is considerable overlap between the groups, some of those actually certified being less often "certified" in this experiment than some of those actually rejected. When the opinions of observers E and F (of the Silicosis Board) are considered alone, the overlap still exists, but the actually certified films were "certified" on the average three times more often than the actually rejected films, instead of, for the whole group of observers, only twice as often.

PART II. FURTHER ANALYSIS

Arithmetical Methods.—Hitherto we have discussed the observers' inconsistencies and the disparities between their opinions in terms only of simple differences of categories. We felt that it might be interesting to go further into these questions, and to examine any trends of opinion which might be found and to derive indices which would measure them. Factors of interest include the relative accuracy of observers in the interpretation of chest radiographs of pneumoconiosis and the relative difficulty of interpretation of the different

TABLE 7

FREQUENCY OF "CERTIFICATION" OF FILMS ACTUALLY CERTIFIED OR REJECTED BY THE SILICOSIS MEDICAL BOARD

Film No.	Observers A–K		Observers E and F	
	No. of certifying opinions	Frequency of certification (%)	No. of certifying opinions	Frequency of certification (%)
Rejected :				
1	8	40	1	25
2	7	35	1	25
3	4	20	1	25
4	1	5	0	0
5	4	20	1	25
6	10	50	2	50
7	2	10	0	0
8	1	5	0	0
9	0	0	0	0
10	7	35	3	75
11	2	10	1	25
12	5	25	1	25
13	7	35	1	25
All films	58	22	12	23
Certified :				
1	3	15	2	50
2	3	15	2	50
3	5	25	1	25
4	12	60	4	100
5	13	65	4	100
6	14	70	4	100
7	9	45	3	75
8	16	80	3	75
9	11	55	4	100
10	10	50	3	75
11	1	5	1	25
All films	97	44	31	70

groups of films and stages of disease included in our material. In order to do this we have treated the category numbers employed in our experiment as if they were actual numbers and have used them for statistical processes, such as the averaging to which we have already referred.

To do this is to make the assumption that the stages of pneumoconiosis represented by the five category numbers lie on a linear scale of increasing radiographic abnormality. How justifiable this assumption is it is not easy to decide, but two possible ways in which it might be considered false can be considered. First, the range of abnormality covered by each category might not be the same, one category perhaps extending over a wider range than the others. It would then follow that errors or inconsistencies of diagnosis would have different significance at different places in the range.* Second, there is a difference of character in category 5 which makes it rather distinct from the others. Films were placed in this category if in addition to "reticulation" the observer considered there was definite nodulation or an area of coalescent shadowing. Thus, while the distinction between the first four categories was chiefly quantitative, a qualitative element entered into the differentiation of category 5.

We have proceeded to use the category-numbers for calculation without making any allowance for the effects of these or other factors. It seems reasonable to suppose that the validity of our results will not be seriously affected, in particular if the results are regarded as indicating general trends rather than precise measurements.

Bias of Observers.—We now proceed to see if the discrepancies of opinion that have been discovered show any consistent trends, such as persistent bias of certain observers towards over- or under-classification of the films. The existence of such trends would be demonstrated by differences between the average opinion of all observers and the average opinion of a particular observer in the different groups of films.

These differences are given in Table 8, and are presented diagrammatically for the whole group of films in fig. 7. It will be noted from the table that with a few exceptions each observer does show a consistent bias from the general average in each group of films. Observer D, for example, places the films in categories higher than the average and observer K in categories lower than the average.

In attempting to assess the degree of abnormality in a radiograph of pneumoconiosis the observer must compare it with mental pictures—or standards—built up from his past experience of such radiographs. These mental standards may be entirely subjective, but they may include partly objective criteria such as the extent of the lung field in which abnormality appears or the degree of obscuration of the lung markings. The fact that the bias of the individual observers' average opinions is consistent in its direction throughout the various groups of

* This point has been investigated, and the results suggest that category 1 covered a slightly wider range than the others. The method used was to find positions in the range of abnormality where the upper boundaries of categories 1, 2, 3, and 4 should fall in order that the average amount of disagreement over each film remaining after the bias of each observer was allowed for should be least. These positions were found to be such that categories 1, 2, 3, and 4 occupied respectively 32, 21, 26, and 21 per cent. of the range from absolute normality to the lower boundary of category 5, instead of occupying 25 per cent. each.

TABLE 8

DIFFERENCES BETWEEN THE AVERAGE OPINION OF EACH INDIVIDUAL OBSERVER AND THE AVERAGE OPINIONS OF ALL OBSERVERS

Observer	Victor Medium	Victor Soft	Victor Hard	H. and A films	Si.B. films	All films
A	+0·073	+0·020	+0·234	+0·200	+0·185	+0·146
B	−0·027	−0·202	+0·067	−0·116	−0·315	−0·129
C	−0·027	+0·202	−0·044	+0·400	+0·310	+0·214
D	+0·399	+0·572	+0·652	+0·268	+0·456	+0·409
E	−0·227	−0·147	−0·321	−0·366	−0·106	−0·242
F	+0·306	+0·520	−0·155	+0·150	+0·435	+0·268
G	+0·323	+0·353	+0·790	+0·050	+0·144	+0·244
H	+0·057	−0·313	+0·290	−0·050	+0·081	+0·018
J	−0·227	−0·480	−0·599	+0·250	−0·461	−0·124
K	−0·644	−0·702	−0·877	−0·783	−0·731	−0·732

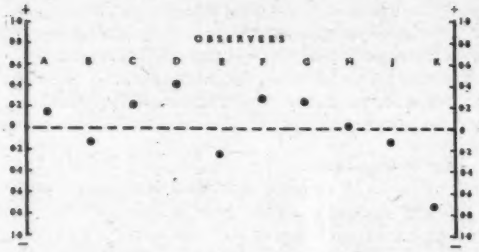

FIG. 7.—Differences between average opinion of each observer and average opinion of all observers. The average opinion of all observers is represented by the horizontal dotted line and the average opinion of each individual observer by solid circles. The vertical axis is marked in category numbers.

films suggests that during the experiment each observer derived his own individual set of mental standards from the written definition of the categories, and from his own experience. The smallness of the average deviations shows that, with the exception perhaps of observers D and K, the mental standards of all the observers were very similar.

Inconsistency of Observers.—The inconsistency found between the first and second opinion given by each observer might be due either to the difficulty he found in matching the films with his mental standards or to a change in his mental standards between the two occasions, or to both.

A change in an observer's mental standards between the two occasions would be suggested by finding a difference between the average of his first and second readings which should be consistent in sign for each group of films.

The differences between the average of the first and of the second opinion of each observer are given in Table 9 and are plotted diagrammatically in fig. 8. It will be seen that while some observers (for example B, C, D, and E) on the average maintain their mental standards practically unchanged on the two occasions, others (for example G, H, J, and K) noticeably lowered their mental standards between the two readings, thus giving a higher average opinion on the second occasion, while observer A raised his slightly, giving a lower average opinion on the second occasion.

Skill and Experience.—The observers in this trial all had different experience of the radiographs of coalminers' pneumoconiosis, and it is interesting to see if the skill each observer showed can be related in some way to his experience.

The particular kind of skill that was necessary in this experiment can be separated into two components. The observer must first be able to assess the degree of abnormality of the radiograph in terms of the categories that were adopted, and, secondly, he must be able to perform this classification consistently on two occasions. For the consideration of the first type of ability we are faced with the difficulty, discussed by Yerushalmy (1947) of establishing the correct category of each film with which the various opinions of the observers may be compared.

TABLE 9

MEAN DIFFERENCES BETWEEN SECOND AND FIRST READINGS OF EACH OBSERVER

Observer	Victor Medium	Victor Soft	Victor Hard	H. and A. films	Si. B. films	All films
A	−0·133	−0·111	−0·444	−0·133	−0·250	−0·186
B	−0·067	−0·111	−0·333	−0·033	−0·083	−0·088
C	−0·100	0	−0·333	−0·067	0	−0·078
D	0	+0·222	−0·111	−0·067	−0·125	−0·039
E	+0·233	0	0	−0·067	+0·042	+0·059
F	+0·133	0	+0·111	+0·033	+0·250	+0·118
G	+0·300	+0·111	+0·444	+0·300	+0·417	+0·324
H	+0·233	−0·111	+0·111	+0·233	+0·458	+0·245
J	+0·067	+0·333	+0·111	+0·167	+0·458	+0·216
K	+0·300	+0·444	+0·667	+0·167	+0·250	+0·294
(L)	(+0·133)	(+0·667)	(0)	(+0·300)	(−0·167)	(+0·088)

FIG. 8.—Changes in the average opinion of each observer between the first and second readings. The change in the average opinion of each observer on the second reading is represented by the distance, positive or negative, between the appropriate solid circle and the horizontal dotted line. The vertical axis is marked in category numbers.

We have approached the question by trying to decide the category into which each film would be placed if the ten observers were discussing it in consultation. Presumably this would be, in most cases, the category into which the largest number of observers placed the film. In some cases, however, this "modal" opinion was unsatisfactory. For example, one of the H and A films was assessed during the trials as follows :

9 opinions of category 2
5 opinions of category 3
4 opinions of category 4
2 opinions of category 5

The modal opinion here is category 2, but the majority of the observers put the film into a higher category. Consultation would probably lead to acceptance of the category nearest to the average as the final opinion (in this case category 3), and this is the rule we have adopted. Each film was given a *standard category* which was *that category nearest to the average opinion of all observers*. The category nearest the average, and not the average itself, must be used as the standard, since by the terms of the experiment the observer had to allocate each film to a particular category and could not use fractions of categories for border-line films. The standard category of the corresponding medium film was always taken as the standard category of Victor Soft and Hard films.

The lack of bias of an observer at classifying the films can now be measured by the smallness of the deviation of his opinion, on the average, from the standard categories. In the same way, his consistency of classification can be measured by the average difference between his first and second opinions on the same film. In each case the difficulty of dealing with positive and negative deviations can be met by taking the average of the squares of the deviations.

In this way we obtain two indices, the Index of Disagreement (I_D) and the Index of Inconsistency (I_C), which measure the two components of the skill shown by an observer. I_D will be zero when the observer agrees with the standard category of each film, and it will increase with increasing amount of disagreement with the standards up to a maximum which depends on the distribution of standard categories in the group of films but which cannot exceed 16. In fact, the indices of the observers seldom exceed unity in any group of films. When the numbers one to five were allocated at random as assessments of the films, the index of disagreement was found to be 4·8, so we might expect the I_D of a completely unskilled observer to be of this order of magnitude. I_C will be zero for a perfectly consistent reader, and will increase with the degree of inconsistency of the reader to a maximum of 8 attainable only if extreme and opposite opinions are expressed on every film.

Symbolically, the two indices are given by :

$$I_D = \sum_{i=1}^{n} (x_i + y_i - z_i)^2/4n$$

$$I_C = \sum_{i=1}^{n} (x_i + y_i)^2/2n$$

where x_i and y_i are the first and second opinions of an observer on the i^{th} film of a group of n, and z_i is the standard category of the film.

Neither the index of disagreement nor the index of inconsistency alone gives a fair index of the "skill" of each observer in the sense in which we are defining it. A good observer might consistently differ from the standard opinion (perhaps correctly if some absolute standard could be achieved) so that I_D alone is not sufficient as a measure of skill. Similarly I_C on its own is inadequate, for an observer intent on consistency might formulate rules for the assessment of difficult films which would ensure his two opinions being the same on two occasions. He might, for example, decide to call all such films—or indeed every film—category 3, in which case his I_C would certainly be zero. But inevitably in such a case his I_D would be large. In order to establish a satisfactory index for the individual observer's skill we need to consider both indices in conjunction. This is most simply done by taking the average of the two, thus obtaining an index, I_S, equal to $\frac{1}{2}(I_D+I_C)$. The three indices for each observer are given in Table 10, and fig. 9 shows them graphically.

It is interesting to note the very good performance

TABLE 10

INDICES OF DISAGREEMENT AND INCONSISTENCY, AND COMBINED INDEX

Observer	Index of disagreement	Index of inconsistency	Combined index	Ranking
A	0·245	0·128	0·187	2
B	0·223	0·093	0·158	1
C	0·453	0·240	0·347	6
D	0·539	0·236	0·388	7
E	0·277	0·196	0·237	3
F	0·466	0·187	0·327	5
G	0·473	0·304	0·389	8
H	0·341	0·231	0·286	4
J	0·534	0·383	0·459	9
K	0·725	0·275	0·500	10
(L)	(0·738)	(0·332)	(0·535)	(11)

of observers A and B on all indices. It will be remembered that these observers had had the greatest experience of all in the accurate classification of radiographs of coalminers' pneumoconiosis. A and B are followed by the Silicosis Board observers and the tuberculosis physician who had continued work amongst miners in South Wales. The relatively inexperienced medical scientists come next, followed by G who had worked with the Pneumoconiosis Research Unit and the Silicosis Medical Board; his combined index is lowered by a high index of inconsistency due to a large systematic shift in his opinions on the second reading (fig. 8). The final group of observers with least skill includes the tuberculosis physician who had not worked among cases of pneumoconiosis for some years, the London radiologist with little current experience of pneumoconiosis, and observer K who has a low index of skill owing to his relatively consistent under-estimation of the films (see fig. 3). It appears that the combined index does give the observers rankings which might be expected from their varying experience.

TABLE 11

AVERAGE VALUES OF THE DIFFICULTY-OF-AGREEMENT INDEX
(No. of films in each group given in brackets)

Group	Standard category				
	1	2	3	4	5
Victor Medium ..	0·50 (3)	0·61 (7)	0·49 (9)	0·36 (6)	0·36 (5)
Victor Soft ..	—	1·00 (3)	1·15 (4)	0·35 (2)	—
Victor Hard ..	—	0·57 (3)	0·58 (4)	0·38 (2)	—
H. and A. films..	0·25 (4)	0·54 (10)	0·64 (7)	0·40 (8)	0·35 (1)
Si. B. films ..	—	0·60 (1)	0·69 (18)	0·59 (5)	—

Relative Difficulty of Films.—It has been shown in Table 1 that the range of opinion expressed on certain films was greater than on others. It seemed worth investigating this point further, although the experiment was not designed with this end in view and the material is not entirely satisfactory for the purpose.

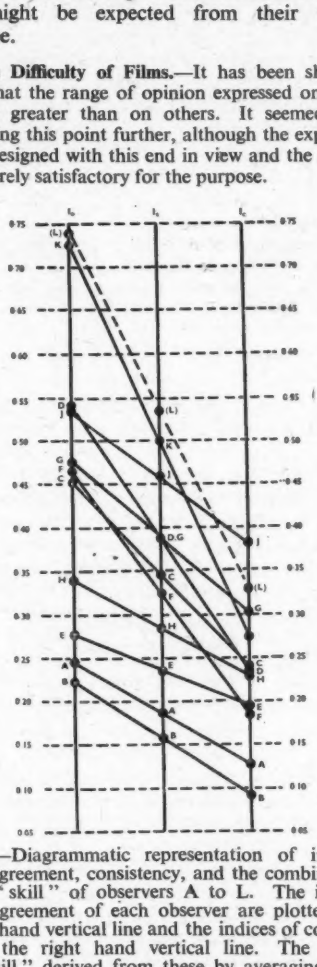

FIG. 9.—Diagrammatic representation of indices of disagreement, consistency, and the combined index of "skill" of observers A to L. The indices of disagreement of each observer are plotted on the left hand vertical line and the indices of consistency on the right hand vertical line. The index of "skill" derived from these by averaging is given on the central vertical line. The values for the index of disagreement are much greater than the values of consistency because of the much greater divergence found between the opinions of the different observers than that found between the two opinions of each observer.

As a measure of this relative difficulty of classification of a film the mean square of the difference between each expressed opinion and the standard category of the film may be used, that is :

$$\sum_{i=1}^{20} (x_i - z)^2/20$$

where x_i is an individual opinion of the film and z is its standard category. (There are, of course, twenty individual opinions on each film.)

The size of this index increases with the amount of disagreement found in the classification of each film, both between the observers and within an observer's own two opinions. Fig. 10 is a histogram of the number of films falling within certain ranges of value of this "difficulty-of-agreement" index. It will be seen that the distribution is roughly of Normal form between the limits 0 and 1·1, and that there are four films above this range. Three of these were Victor Soft films, and the remaining one a "Si-B" film. This suggests that technique may influence the size of the index of film-difficulty, and that it might be of interest to examine the relative difficulty of the different groups of films used in this experiment.

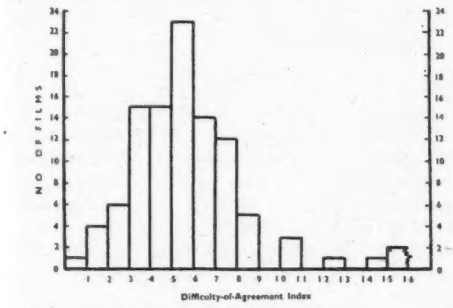

FIG.10—Histogram of the distribution of films according to the size of their difficulty of agreement index.

The average values of the difficulty-of agreement index for the different standard categories are given in Table 11. It appears that the difficulty of the different standard categories as measured by this index agrees with what would be expected. Categories 1, 4, and 5, which represent the extremes of the range of abnormality with which we are concerned, were found easier to agree about than categories 2 and 3, which subdivide the intermediate range.

There is some disagreement among various workers concerned with pneumoconiosis as to the best radiographic technique to use for the diagnosis of the disease. It might be thought that the difficulty-of-agreement index could be used to obtain an objective measure of the value of different techniques. The results of our experiment do not encourage this supposition, for we find that the Victor Medium and "H and A" films have much the same indices within corresponding categories, although it would be generally agreed that the Victor Medium films were superior in technique. Further, although the Victor Soft films have very high indices, the Victor Hard films have low indices despite gross over-penetration. However, this latter conflict with expectation may be due to the small number of films in each group. Further work is necessary to establish the value of the index.

Effect of Practice and Fatigue.—It would be of interest to know whether the performance of an observer classifying radiographs gets better or worse towards the end of a long series; in other words whether his skill improves temporarily as a result of practice, or whether fatigue has a dominating effect and the last films are read with less skill than the first. In this experiment the films were read first in order 1 to 102 and second in the reverse order 102 to 1. In consequence, the first and second readings of each film occurred at the same interval from the beginning and end respectively of each observer's trial and there is no way of detecting changes of an individual's consistency with time. But by treating all first and second readings separately we can detect trends in the magnitude of the "difficulty-of-agreement" index by calculating its linear regression against film serial-number. The resulting equations are:

$$\text{1st Trial}: \quad V = 0{\cdot}75 - 0{\cdot}0022n.$$
$$\text{2nd Trial}: \quad V = 0{\cdot}55 + 0{\cdot}00014n.$$

where V stands for the value of the "difficulty-of-agreement" index and n is the serial-number of a film. In each trial therefore, V is slightly smaller at the end than at the beginning, so that there is a suggestion that the observers' assessments agreed better after they had been reading films for some time than when they first begin the trials. Further investigation would obviously be necessary before it could be said definitely that practice had more effect in increasing the skill with which films were read than fatigue has in decreasing it.

Discussion

A certain amount of care is necessary in drawing general conclusions from the results of this experiment. The set of films used was specially made up with certain problems in mind, and was not necessarily typical of any set that might be encountered in practice. The comparison of the skill of the different observers has been made in relation only to the problem of classification in pneumoconiosis, and obviously would not hold for work in other fields. The assumptions that have been made in treating the five categories as if they were numbers have already been pointed out; these assumptions may perhaps be more easily appreciated if it is considered that the categories might equally well have been called A, B, C, D, and E, and the meaning of the "average opinion" of a film, for example, would then have been much less obvious. The purpose of the investigation was to establish the existence of inconsistency in *x*-ray interpretation and to provide measures of it, in order that the value of other methods of interpretation might subsequently be estimated. We believe that for these purposes the methods we have employed are valid. If the reservations made above are borne in mind, certain general conclusions may with confidence be drawn from the results.

The assessment of the degree of abnormality due to pneumoconiosis in any film by even an experienced observer is not an absolute one. It will frequently differ to an extreme degree from the opinions of other observers and will often differ to a lesser degree from the same observer's opinion on the same film on a subsequent occasion. We have suggested that these varying opinions are due to the observer matching the film under consideration with mental pictures derived from his experience. These mental pictures vary from observer to observer and within one observer from time to time.

An analogy with another sort of clinical assessment may be used to illustrate this point. A patient's hæmoglobin level may be measured by an assessment of the redness of a diluted specimen of blood. If the method used by the radiologist were employed, the pathologist would just hold the specimen to the light and classify it in comparison with a mental standard of redness. In fact, the pathologists have found this method unsatisfactory and have come to use standard colour tubes for direct comparison and have thus achieved a far greater degree of accuracy. But even so, it has been shown that standards may vary in their precise tints and that the technique of comparison may greatly influence the opinion given by the pathologist. For greater consistency it has been found necessary to lay down very precise instructions for such comparative estimations (Macfarlane, 1945).

It might be suggested that radiologists should follow this method in the diagnosis of pneumoconiosis, using standard films for comparison. The problem in this case is not quite so straightforward, however. Radiographs of pneumoconiosis differ not only in the degree of abnormality but also in type of abnormality. For this reason, standards of each type would be required. This difficulty, however, should not be an insuperable one. Further, the present experiment has shown the great influence of radiographic technique on the opinion of most observers. This difficulty could be lessened by strict regulations of the radiographic technique to be employed.

The question of the accurate radiological diagnosis of pneumoconiosis is one of considerable importance, in view of the weighty decisions which rest upon it. At present, the chest radiograph forms the main basis on which decisions are reached concerning the occupational future and economic compensation of men working in industries with a silicosis risk. For such decisions, the inaccuracies of diagnosis revealed in the experiment here described are far too great. The inaccuracies are also of great importance in research. For example, they will seriously affect the results of radiological surveys undertaken to estimate the prevalence of the disease under different environmental conditions. They will also affect the results of studies of progression, of methods of prevention and treatment, and of the value of special radiological methods, such as miniature films, in the diagnosis of the disease.

Further study is necessary to establish means of reducing and compensating for these inaccuracies. We have already carried out a preliminary trial with standard films which leaves little doubt that, with their assistance, it is possible for observers to achieve a greater degree of agreement and consistency in classifying radiographs of pneumoconiosis than that shown in the experiment we have reported. We are now engaged upon an experiment intended to provide a more precise assessment of the uses and limitations of such standards. The results of this experiment will be reported later.

Summary

1. Very little is known of the errors inherent in the detection of pneumoconiosis by means of radiographs and in the classification of radiographs of pneumoconiosis according to the severity of the disease, although accurate detection and classification is essential in research, in industrial health surveys, and especially in reaching decisions concerning compensation for industrial diseases of the lung.

2. Ten doctors, with varying experience in the radiological diagnosis of coalminers' pneumoconiosis in South Wales, were asked to classify 102 radiographs of early coalminers' pneumoconiosis into five categories. Each doctor classified all the films on two separate occasions. In addition two consultant radiologists, working in London, subsequently undertook the same repeated classification of the radiographs.

3. The opinions of these observers were found to differ to a remarkable degree, both amongst themselves, and, to a lesser extent, from the one occasion to the other. The divergence of opinion between the two consultant radiologists was as great as between the ten other observers. The variation of opinion was greatest in films that were neither normal nor grossly abnormal.

4. There was serious disagreement concerning the limits within which a film may be regarded as normal. Thus, there were 32 films which were considered to be within normal limits by one or other of the observers, but to show " certifiable " pneumoconiosis (that is, sufficient to merit compensation under the Workmen's Compensation Acts) by at least one other of the observers.

5. The number of films considered "certifiable" on both occasions by the various observers ranged from 5 to 45. On one of their readings, two colleagues from the Silicosis Medical Boards "certified," respectively, 34 and 53 of the films. A review of cases applying to the Silicosis Medical Boards during the first half of 1948 showed that 22 per cent. of them fell into the class on which the opinions of these doctors concerning certification might differ.

6. Radiographic technique was found to have a seriously disturbing effect on classification. Underexposed films were generally considered to show more disease than over-exposed films of the same case taken on the same day. Some observers were less affected than others by this factor.

7. A statistical analysis of the results was made in order to show the general trends in the differences of opinion between the observers and between the opinions of the same observers on the different occasions, and to derive indices of the relative skill of the observers, and of the relative difficulty of diagnosis of the various films. The validity of the methods used is discussed and is accepted for these comparative purposes.

8. It is suggested that the amount of inconsistency of opinion that was found is intolerable in view of the important consequences of the radiological diagnosis of pneumoconiosis, and that the present method by which films are diagnosed by simple scrutiny should be superseded by a method of comparison of unknown films with accepted standard reference films. A further experiment is being planned to investigate the possibilities of this method.

We wish to pay tribute to the courage of the observers who allowed us to examine their competence by such stringent standards as those that we have employed. We wish also to thank Dr. P. Hugh-Jones for his advice in the design of the experiment and for his help in some of the analyses.

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TALC PNEUMOCONIOSIS

BY

A. I. G. McLAUGHLIN
H.M. Medical Inspector of Factories

ENID ROGERS
Member of the Silicosis Medical Board

AND

K. C. DUNHAM
Chief Petrographer, H.M. Geological Survey and Museum

(RECEIVED FOR PUBLICATION, DECEMBER 20, 1948)

In September, 1946, we had the opportunity of examining the lungs of a man who had died from rheumatic endocarditis and pneumoconiosis and who for most of his industrial life had been exposed to talc dust.

Case History

He was 51 years of age and had worked since he left school at 14 years of age in a rubber tyre factory for thirty-seven years. The only break in this employment was a period of four years' service in the 1914–18 war, mostly spent in India. In the factory he had worked on a tyre-extruding machine. While a tyre is being extruded, powdered talc (or French chalk) is gently blown through it by means of compressed air to prevent the rubber surfaces from sticking together. The tyre is cut into suitable lengths and the outer surfaces are patted with talc powder. Exhaust ventilation devices are installed to prevent gross contamination of the air with dust, but it is likely that over a period of years there had been considerable exposure to talc dust arising mainly from the open end of the tyre and during the patting operation.

Inquiry into the man's family history showed that his father had died from "blood pressure" and his mother from dropsy; his two brothers had both recently died, one from a gastric ulcer and the other from a sudden heart attack. He himself had suffered from chorea at the age of 12 years, the attack lasting for seven months. Since then he had no further illness and had led a strenuous athletic life until 1939, when he began to suffer from a persistent pain in the right hypochondrium. His alimentary tract was radiographed at hospital, but nothing was found to account for the pain. In December, 1944, he was admitted to hospital for observation because he still complained of the pain. In hospital it was noticed that he was short of breath while lying in bed. A radiograph of the chest was taken and it was reported that he had an "industrial chest" or "fibrous lung." On return to work after 10 weeks' absence he was given a job as a gatekeeper.

On clinical examination by one of us (A.I.G.McL.) in August, 1945, the man was found to be fairly well nourished, slightly dyspnœic at rest, but with no obvious cyanosis of the extremities, face, or ears; there was no clubbing of the fingers and no œdema of the legs. The chest measured 34 inches with an excursion of two inches between deep inspiration and forced expiration, that is to say, the chest movement was diminished. The breath sounds were distant over the whole of the lung fields (a common finding in the pneumoconioses), but no other abnormal signs were found. Signs of well-marked aortic incompetence with hypertrophy of the left ventricle were also present. The pulse rate was 80 per minute, and the blood pressure 170/90 mm. Hg. When the abdomen was examined there was slight tenderness over the right hypochondrium, but the liver was normal in size and ascites was not present. Other systems were normal.

***X*-ray Examination.**—By the courtesy of Dr. J. S. Harper, County Tuberculosis Officer for Wiltshire, we were able to see a series of *x*-ray films of the chest taken at intervals of six months from February, 1945, until August, 1946. Three of them are reproduced here (figs. 1, 2, and 3). They all show the enlargement of the heart shadow, and small closely packed nodular shadows in both lung fields. Those on the right side are clearly defined, whereas those on the left are "fluffy" and indistinct. The line of the right diaphragm is clear, whereas that of the left is blurred. The last film (fig. 3) taken shortly before his death shows much increased basal mottling, which, taking into account the short interval since the previous film, may be interpreted as shadows of lung congestion from a failing heart.

Dr. Harper, who had kept the patient under observation for some years, did not find bacteriological or clinical evidence of pulmonary tuberculosis. The man died in August, 1946, and a post-mortem examination was made by Dr. E. M. Darmady of Salisbury. He sent us the lungs for more detailed examination. The causes of death were (1) congestive heart failure due to long-standing rheumatic endocarditis, and (2) pneumoconiosis.

Pathology.—The lungs had been fixed in formalin before they were received. The root glands were moderately enlarged but not fibrotic. Except for adhesions over the right base, the pleuræ were normal. The whole of the left lung and the lower lobe of the right were moderately congested. Throughout the lung substance were scattered small grey nodules, more numerous in the lower lobes. In the right lower lobe and in the upper pole of the left lower lobe the nodules had coalesced to form small masses. These confluent lesions bore some superficial resemblance to infective silicosis

but no naked-eye evidence of tuberculosis was present in either lung. A moderate degree of emphysema was apparent in those parts of the lungs free from congestion. The isolated nodules were small, rarely exceeding 2 or 3 mm. in diameter, poorly defined, and only just palpable. They felt tough rather than hard, and lacked the compact pattern of classical silicotic nodules.

On microscopic examination the nodules were seen to consist of loosely woven fibrous tissue. The larger nodules were made up of the coalescence of a number of smaller ones, the fibres appearing to be arranged concentrically round small vessels, giving the impression of whorling but not quite in the pattern characteristic of silicosis. Many of these vessels had fibrous thickened intima. Some nodules were in close relationship with a respiratory bronchiole and in this respect resembled the lesions of asbestosis, silicosis, and coal-miners' pneumoconiosis, but no focal emphysema was seen (figs. 4 and 5). Some dust particles within phagocytes appeared at the periphery of each nodule; within the nodule itself were many fibre-like structures up to 40μ in length arranged singly and in clumps. Some "curious bodies," very like asbestosis bodies (figs. 5, 6, and 7) were also seen. Under polarized light all nodules were found to be closely packed with doubly refractile particles, each resembling a short fibre; no flake-like particles were visible. The nature of the fibres is discussed below.

In all sections studied there were found small numbers of "curious bodies" resembling but not completely identical with asbestosis bodies. They were mostly single, but occasionally in clumps of three and four seen usually at the edge of a confluent lesion. One was found amongst the débris in an alveolus. In scrapings from the cut surface of a nodule they were fairly numerous. They were pale lemon-yellow rods, rather like dumb-bells, the end-masses often consisting of rosettes, which could sometimes be found separate from the rods in the lung tissue. They had a somewhat finer central core than asbestosis bodies and did not show such variation in shape. Like asbestosis bodies they gave a positive prussian blue reaction.

The presence of these curious bodies led to a further investigation of the industrial history. Asbestos had never been used in the factory where the man had been employed. On the other hand asbestine, a fibrous variety of talc, had been used from time to time in the factory, but not on the rubber extruding machines. The mineralogy of the dust particles in the lung, described below, show that the majority were in the form of short fibres which could easily have formed the basis of the curious bodies by the deposition of iron salts on them.

Curious bodies closely resembling these and the true asbestosis body have been found by one of us (E.R.)in South African gold miners who had never worked in the asbestos industry (Williams, 1939) while "black-cored" curious bodies are often found in the lungs of coal-miners and coal-trimmers (Williams, 1934). The findings in each of these two investigations suggested that they were due to the chance inhalation of a fibrous mineral not necessarily related to asbestos or coal.

Chemical Analysis.—The right lung from the present case was sent to Dr. H. E. Harding of the University of Sheffield for chemical analysis. We are indebted to him for the following report:

Ash	.. ..	15·10% of dry weight
Fe (as Fe_2O_3)	..	1·16% " " "
Total silica	..	5·31% " " "
Free silica	..	0·52% " " "

Dr. Harding suggested that owing to technical difficulties the last two figures were probably too high, and he later submitted the ash to *x*-ray analysis. He reported that the ash gave only a very faint quartz line, suggesting that there was less than 1 per cent. of quartz present and therefore probably less than 0·06 per cent. of free silica.

Occurrence of Talc

Talc is hydrated magnesium silicate ($Mg_3Si_4O_{10}(OH)_2$) and in its compact form is known as steatite or soapstone. It is mined in such parts of the world as U.S.A., Canada, France, Italy, Norway, and India, and it occurs in both flaky and fibrous forms. Jones (1943) says that the chief deposits of talc and soapstone occur in altered magnesia-rich calcareous rocks such as dolomite, marble, and magnesian limestone. The purest talc deposits occur in association with dolomite and marble. Talc also occurs in altered basic rocks such as serpentines, and again as thin beds in mica schists. "The largest talc deposit in Europe, on the northern slope of the Pyrénées, occurs as beds in mica schist." Commercial talcs contain a number of related minerals and impurities. They may include antigorite (hydrated magnesium silicate), magnesite or members of the magnesite—chalybite series of carbonates, dolomite (calcium magnesium carbonate), tremolite (calcium magnesium silicate), and spinels (chromite, magnetite, etc.). Talc rarely occurs in association with free quartz and commercial talcs are normally free from quartz. It may be recalled that asbestos is the commercial name applied to the fibrous amphiboles, including tremolite, actinolite, anthophyllite, and crocidolite. These differ from talc in consisting wholly or largely of acicular crystals, though, as noted below, talc may in certain instances arise as an alteration-product of tremolite; it may replace anthophyllite also, inheriting in both cases an imperfectly fibrous form.

Mineralogy of the Particles in the Lung

An investigation of the mineralogy of the contents of the lung, and of the talc used in the factory was carried out in the petrographical laboratories of the Geological Survey. Sections of the lung had, as already noted, revealed numerous birefringent particles (figs. 8, 9, and 10). These proved to be straight or (rarely) slightly curved fibres, showing positive elongation and extinction parallel with the

plane of polarization of the light. Separation of the mineral from the lung tissue was carried out by Mr. C. O. Harvey by means of the following procedure, adopted to avoid as far as possible any chemical or physical alteration of the inorganic silicate material :

The lung sample was moistened with 40—" vol " H_2O_2 and allowed to stand for a few minutes ; 10% NaOH was then added and complete disintegration of the tissue was effected by boiling ; after centrifuging, boiling with 10% NaOH was repeated. The residue was then centrifuged, washed with water, centrifuged, and digested with hot 4N HCl. After further centrifuging, and washing with water and ethyl alcohol, the sample was shaken with $CHCl_3$, boiled for a few seconds, cooled, centrifuged, and washed with ether.

Microscopical examination of the residue (ENQ 933*) showed that the organic tissue had been completely removed. The residue consisted almost entirely of straight fibres, somewhat curved fibres, and shreds having maximum refractive index 1·589, the Z-direction being parallel with the length of the fibres. The minimum refractive index of the fibres was near or slightly below 1·546. The fibres ranged up to 10 microns maximum length, but many were 4-5μ long. A few plates up to 5μ diameter, showing low birefringence and refractive index near 1·589 were noted. An exhaustive search for fibres of amphibole showing inclined extinction failed to reveal any such fibres. A few tiny granules of an opaque substance were noted in the powder.

The accepted mineralogical data for talc shows that it is a platy mineral with Z parallel with the basal (001) cleavage, having refractive indices $n\alpha = 1{\cdot}538\text{-}1{\cdot}545$, $n\gamma = 1{\cdot}575\text{-}1{\cdot}590$. The observations on the lung residue are thus consistent with talc except in the acicular habit of the mineral. That the mineral is in fact talc was confirmed by *x*-ray powder photographs of the residue taken by Mr. H. J. Dothie at the Government Laboratory. These are compared with lines shown by a standard sample of talc supplied by Dr. T. A. Lloyd Davies of Boots Chemists Ltd., Nottingham, in fig. 11. Mr. Dothie's measurements of the lines shown by the material from the lung are as follows :

		α		
S	..	9·42	Talc	
M	..	6·88		
M	..	4·59	Talc	
M-S	..	3·58		S, Strong
S	..	3·09	Talc	M-S, Medium-strong
M-W	..	2·59	Talc	M, Medium
M-S	..	2·49	Talc	M-W, Medium-weak
W	..	2·36		W, Weak
W	..	2·21	Talc	
W	..	2·11	Talc	
W	..	2·01	Talc	
W	..	1·885	Talc	
W	..	1·722	Talc	
M-W	..	1·689		
M-W	..	1·530	Talc	
W	..	1·492	Talc	
M-W	..	1·388	Talc	
W	..	1·297	Talc	

* Numbers in brackets refer to slices in the Geological Survey and Museum collection.

Another extraction of material from the lung, carried out with H_2O_2 and NaOH, but without acid treatment, failed to show any particles of carbonate in the mineral residue.

Types of Talc used in the Factory

Up to 1939 the talc used in the factory came from Norway, so that for thirty years the man's exposure was solely to the dust of Norwegian talc. On the outbreak of war, this could not be obtained and the following substitutes were used : (1) " French chalk substitute," a by-product of china clay mining ; (2) Canadian talc and (3) Indian talc, which however was not used on the extruding machines. For the last five years of his working life the man was exposed to the dust of " French chalk substitute " and Canadian talc, but the bulk of his exposure was to the dust of Norwegian talc.

Samples of the Norwegian and Canadian talcs and the " French chalk substitute " were microscopically examined. The Norwegian material (ENQ 935) consisted predominantly of talc with optical properties similar to those displayed by the mineral from the lung. While it was predominantly platy in form, a significant feature was the presence among the finest-grained material of a high proportion of fibres exactly like those in the lung. The sample also contained a substantial proportion of a carbonate having n_ω ranging from 1·714-1·720, probably breunnerite (ferriferous magnesite) though these data are also consistent with a medium ankerite. Extraction with hot dilute HCl gave an approximate figure of 29 per cent. for the carbonate-content of the talc. Very minor quantities of chlorite, tremolite, and titano-magnetite or ilmenite (partly " leucoxenized ") were also noted. A mineralogical report on a different sample, supplied by the owners of the factory, was in general agreement with the above, except that the tremolite was stated to be common among the minor constituents.

The Canadian talc (ENQ 936) showed properties closely similar to those of the Norwegian material ; the carbonate-content of the sample amounted to approximately 28 per cent. and the ordinary-ray refractive index of grains ranged from 1·710 to 1·717. The talc again showed a substantial proportion of fibrous material, particularly in sizes less than 20μ.

Rutile and an opaque spinellid were present in very small amounts.

The " French chalk substitute " (ENQ 934) consisted predominantly of white mica (probably mainly muscovite but possibly including some illite), and kaolinite. Platy forms predominated, but among the smallest material (1-15μ) a proportion of fibre-like shreds was noted. A definite though small amount of free quartz was found; other minor constituents include tourmaline, biotite, and an alkali feldspar.

It will be noted that no evidence of minerals diagnostic of the " French chalk substitute " was found in the examination of the lung residue. The talc could, however, equally well have come from either the Norwegian or the Canadian samples.

The mineralogical observations establish clearly that fine grinding of talc gives rise to material having individual fibre form and perhaps suggest the presence of a previously unsuspected second cleavage parallel with the Z-direction. It has been stated by Berkelhamer (1943) that talc may inherit prismatic-acicular (or long-fibre) form by pseudomorphing tremolite. Thus it might be suggested that the fibres in the samples discussed above originated by alteration of an amphibole. That this is not necessarily the case was, however, proved by examination of talc from Corriecharmaig, Perth (S. 36767A), which occurs as an alteration of a serpentine mass containing no amphibole. Fine-ground talc from this locality shows acicular forms identical with those of the Norwegian and Canadian samples.

Review of Literature

The mineral talc has many uses in industry as a filler for paper, soaps, and paints, as an inert extender, as a dusting powder, and as an absorbent. In the rubber industry talc or French chalk is used freely to prevent the rubber surfaces from sticking together. While a tyre is being " extruded " finely divided talc powder is blown through the cavity by a low-pressure stream of compressed air and the outer surfaces of the tyre are also dusted with the powder. Workers in rubber factories are exposed during the course of their working lives to the inhalation of a good deal of talc dust. Talc pneumoconiosis has been described from time to time, but the number of cases is small enough to suggest that the capacity of the dust to produce fibrosis is low.

In this country Merewether (1933–4) examined 11 rubber tyre workers who had been exposed to the inhalation of talc dust for periods ranging from ten to thirty-two years. He found that the radiographic appearances suggested the presence of a diffuse interstitial fibrosis of the lungs, but that on clinical examination little or no evidence of disability was present. Even after thirty years' exposure only a peribronchial increase of fibrous tissue had resulted. He suggested that the radiographic appearances seen really reflected the actual dust in the lungs, together with any associated congestion, rather than the presence of a diffuse fibrosis. In 1934 he examined thirteen additional workers with exposures ranging from four and a half months to forty years, and the results of examination supported his previous conclusion. The dust of French chalk has in fact been shown to be radio-opaque (McLaughlin and others, 1945).

A few years earlier Zanelli (1931) in Italy described the case of a woman of 27 who had worked for five years in the tyre department of a rubber factory where she had been exposed to clouds of dust. She had complained of gastric symptoms and loss of the sense of smell, and she had hyperæmia of the conjunctiva. *X*-ray films of the chest showed an early tuberculous infiltration in the right subclavicular region, enlarged hilar shadows, diminished transparency of the right lung as compared with the left, and accentuation of the " lymphatic reticulation " of the lung. Later films showed the development of nodulation. No histological studies were made, and the presence of pulmonary tuberculosis also detracts from the value of the case as one of proved pneumoconiosis due to talc dust. The first case to be reported as talc pneumoconiosis also had tuberculosis. This was in 1896 when Thoral of Nuremberg described the pathological features of the lungs of a woman of 44 who had been exposed for several years to the dust of steatite. The lungs were greenish brown, the lower lobes being deeply stained. Masses of pigment composed of steatite dust was found in the alveolar walls and in connective tissue septa, but " there was no formation of agglomerations." Another case was studied by Sand of Belgium in 1910 and mentioned by Carozzi and others. This was a woman who had worked for several years in an atmosphere of talc dust during her exposure. Histologically the lungs showed many talc particles in the alveoli and in the connective tissue, but " without great reaction." Another unpublished case referred to by various authors was that of Cunningham of Toronto. He examined clinically and radiographically a man who had worked for nine years in talc dust and found evidence of pneumoconiosis.

It will be seen that these early reports of talc pneumoconiosis are somewhat inconclusive, but since 1933 investigators in the U.S.A. have devoted a good deal of attention to the subject. Dreesen (1933) examined a number of workers exposed to silicate dusts including fifty-seven in a tremolite talc

mine and mill. Those employed longer than five years showed first-stage pneumoconiosis, the *x*-ray appearances being of a fine bilateral fibrosis. These changes were not accompanied by disability. Dreesen and Dalla Valle (1935) carried out a further survey of two talc-mining and manufacturing plants in Georgia. Clinical and *x*-ray examinations showed that sixteen mill-workers out of thirty-three exposed to high concentrations of dust, and six out of thirteen miners, had pneumoconiosis. In a group exposed to low concentrations of dust no pneumoconiosis was found; five patients with pneumoconiosis also had tuberculosis. It was concluded that Georgian talc was more injurious than tremolite talc.

Nuck and Szcepanski (1939) reviewed the literature of talc fibrosis and added some cases of their own. In a mineralogical study of silicosis, Emmons and Wilcox (1937) demonstrated that both talc and amphibole asbestos may yield on prolonged treatment in blood serum as much soluble silica as does quartz or amorphous silica (opal). Riddell (1940) reported the results of examination of thirty-seven workers engaged in grinding Canadian talc for five to eighteen years; thirteen workers had fibrosis resembling silicosis. In one case under observation for some years the lesions had neither receded nor regressed. Gardner (1940) noted that among three hundred films of talc workers fifty showed some evidence of pulmonary reaction, which in seventeen cases was suggestive of the nodular type. The free silica content of the ore varied from 2 to 20 per cent. In a young man exposed to talc with a rock content of 20 per cent., far advanced discrete nodulation was noted.

Siegal and others (1943) say that "from a survey of the literature it appears that while experimental studies have hitherto been inconclusive, clinical studies have tended to indicate that talc dust is capable of producing injurious pulmonary changes." They report a survey of talc miners and millers in St. Lawrence County, New York, where the talc is of the fibrous variety known as asbestine, and with it is found tremolite; anthophyllite, another fibrous silicate, is also present in these talc deposits. (Jones includes anthophyllite amongst the asbestos group of minerals.) The free silica content is less than 1 per cent. Studies of the dust showed the presence of fine straight needle-like fibres. In a group of 221 tremolite talc miners and millers advanced fibrosis was found in thirty-two men (14·5 per cent.). All cases of fibrosis occurred in men with ten years' and more exposure. The fibrosis was a fine diffuse type with radiographic appearance of granulation or nodulation in a hazy background. It tended to be disabling in character and was often accompanied by dyspnœa, cough, and fatigue. There was some evidence of an increased susceptibility to tuberculosis. An interesting finding was the presence of "talc plaques" in the periphery of the lungs in 6·3 per cent. of all workers examined. These plaques occur in the absence of other abnormal *x*-ray shadows and are not accompanied by signs or symptoms. They conclude that tremolite dust is, like asbestos, capable of causing a disabling pneumoconiosis. It might be interpolated here that Gloyne (1938), in describing the pathology of asbestosis, drew attention to the presence of "stiff, yellow, and horn-like plaques" in the parietal pleura. Porro and others (1942) described fifteen cases of pneumoconiosis among talc miners exposed to an average dust concentration of 52 million particles per cubic foot: five of these cases came to autopsy, and all showed a diffuse fibrosing pneumoconiosis. Asbestosis bodies were found in all five cases, and they suggest that talc pneumoconiosis (in these cases) and asbestosis are the same disease.

Porro and Levine (1946) reported another case of a talc worker of 45 years of age who died from infarction of the lung. Histologically the lungs showed a fibro-cellular reaction with asbestosis bodies.

Reichmann (1944) described twenty-one radiographs of lead plate founders who had been exposed to talc dust. Abnormal shadows began to appear after ten years at work. Pruvost (1946) reported a case of pneumoconiosis in a woman who had been brushing rabbit skins impregnated with talc. The *x*-ray picture resembled pseudo-tumoral form of the silicosis complicated by pneumothorax.

Perry (1947) briefly reviewed the literature of talc pneumoconiosis and illustrated the condition by radiographs of two talc workers: (1) F., aged 48, exposed for twenty years to talc dust in a rubber tyre factory and who had complained of severe cough and dyspnœa; and (2) F., aged 52, exposed for twenty-five years to talc also in a rubber tyre factory, and who had complained of severe cough, purulent sputum, and dyspnœa. No further details were added, but it should be noted that the *x*-ray appearances resembled those seen in asbestosis, illustrations of which are also reproduced in the same paper.

Inhalation animal experiments with talc dust have so far proved inconclusive and it is not possible to deduce from the results of intraperitoneal injections of dust what will be the effect on the lungs. It might be recalled that on intraperitoneal injection asbestos has been classified as an inert dust. On the other hand there have recently been reported many instances, in this country and America, of granulomatous lesions occurring in the tissues as a result of contamination by talc glove-powder during surgical operations. Roberts (1947), writing in the *British*

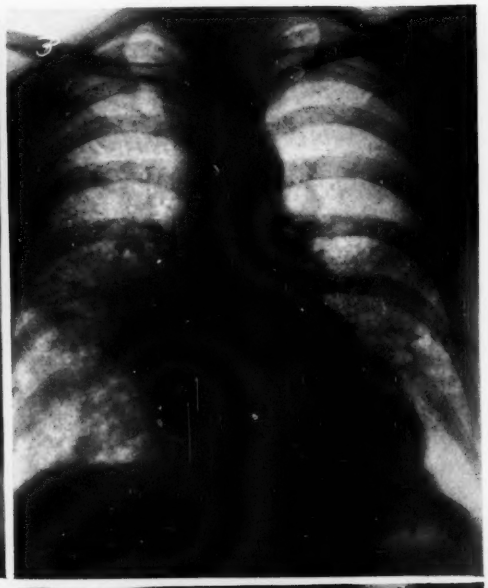


FIG. 1 (top left).—Chest radiograph taken on Jan. 25, 1945, showing nodular shadows distributed generally over both lung fields. There are well-marked root shadows and the heart is large. The line of the right diaphragm is clear, but the left is blurred. Talc pneumoconiosis.

FIG. 2 (top right).—The Chest radiograph taken on Nov. 5, 1945, showed little change.

FIG. 3 (lower).—Chest radiograph taken on March 7, 1946, five months before the patient's death. In addition to nodular shadows shown in two earlier films there is much diffuse shadowing over both bases, probably caused by congestion due to a failing heart.

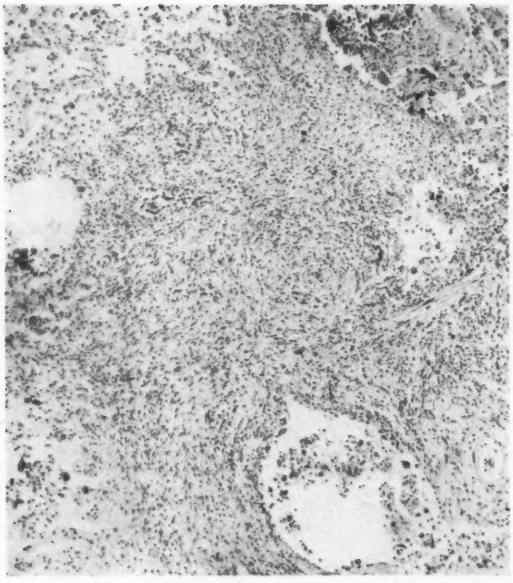


FIG. 4.—Photomicrograph of a fibrotic nodule from the right upper lobe, showing the relation of fibrosis to the respiratory bronchiole, and dust phagocytes at the periphery of the nodule. ×65.

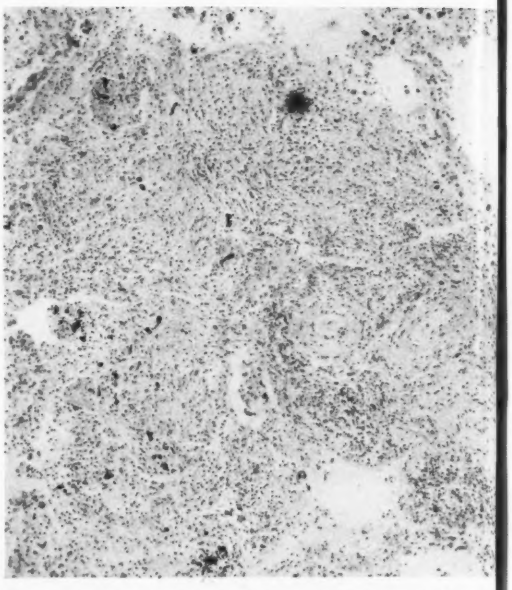
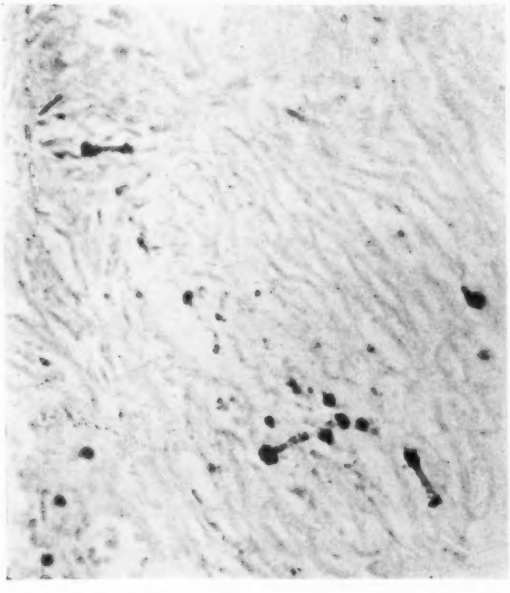
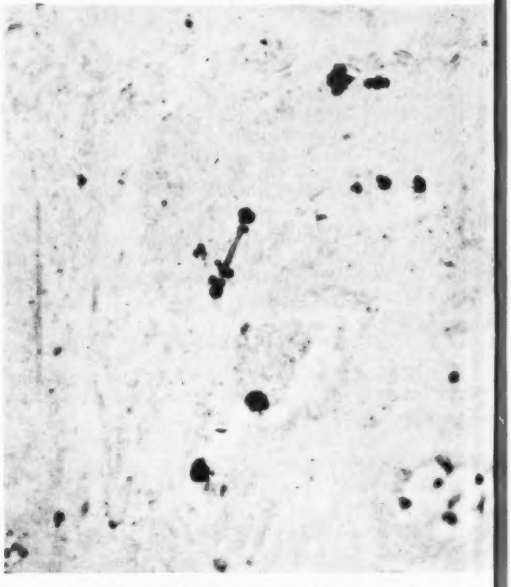


FIG. 5.—Photomicrograph of a nodule from the right apex showing curious bodies. ×65.





FIGS. 6 and 7.—Photomicrographs showing curious bodies. ×350.

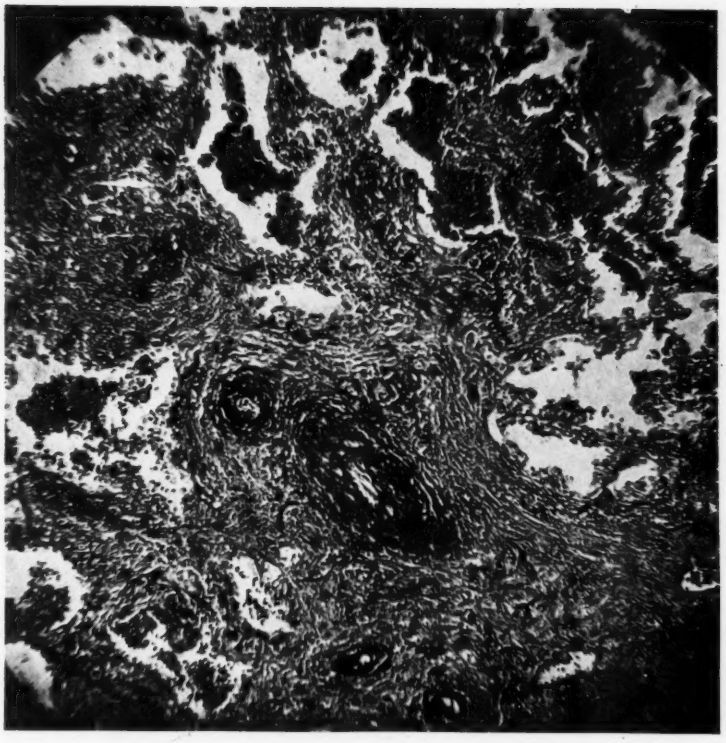


FIG. 8.—Photomicrograph of lung section of worker exposed to talc dust taken on Vickers projection microscope by transmitted light. ×127.

FIG. 9.—Low-power photomicrograph of lung section of the same worker photographed in polarized light on the Vickers projection microscope. The field photographed is a portion of that in fig. 8, and shows birefringent dust particles. ×127.

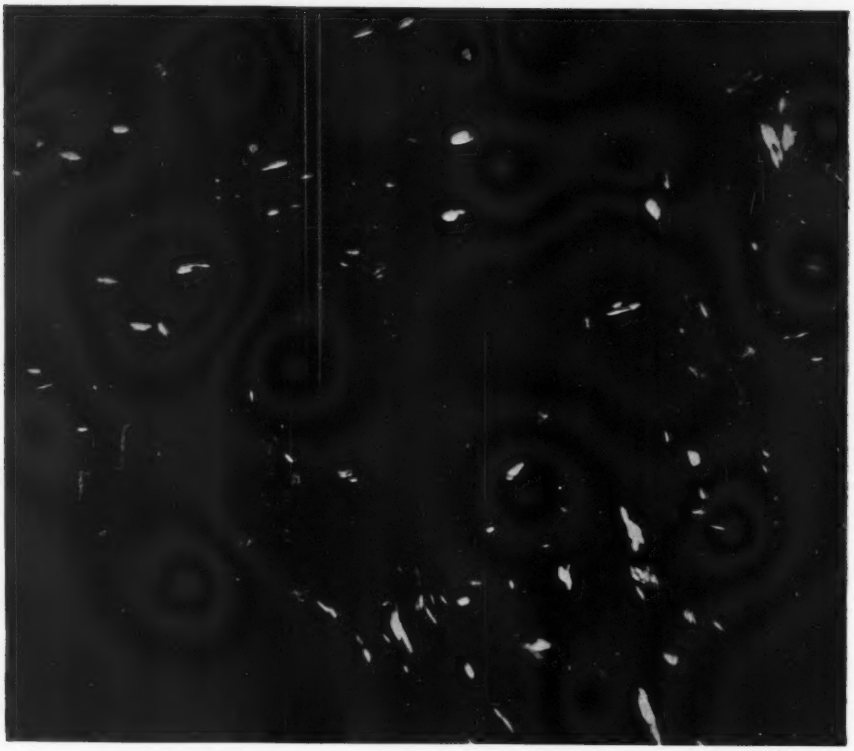


FIG. 10.—High-power photomicrograph of lung section of the same worker photographed in polarized light between crossed polaroid discs on the Vickers projection microscope. The field photographed is a portion of that shown in fig. 9. ×535.

FIG. 11.—*X*-ray powder photographs of mineral extracted from the lung and of talc, taken by Mr. H. J. Dothie at the Government Laboratory, using a 9-cm. camera with Co Kα radiation. P.M. 93 (upper), material from the lung ; P.M. 94 (lower), talc, containing a very small amount of magnesite as impurity ; supplied by Dr. T. A. Lloyd Davies.

Journal of Surgery, describes seven cases of talc granuloma, five of which occurred in the Fallopian tubes following previous operations for appendicitis. Photomicrographs of the lesions show typical granulomatous tissue containing many doubly refractile particles.

Discussion

This is the first case of talc pneumoconiosis proved by pathological examination, to be reported in this country, and it supports the view of the American authors quoted that talc dust can produce fibrosis of the lungs. In this instance the petrographical evidence shows that as a result of prolonged exposure to dust consisting of fibres and plates of talc and equant particles of magnesitic carbonate a substantial quantity of talc fibres has been retained in the lungs. If the plates of talc ever penetrated to the lungs they must for the most part have been eliminated ; similarly no carbonate particles were found in the lungs. It is possible that the dust-eliminating mechanisms, such as the cilia and viscid secretions of the bronchial mucous membrane which protect the lungs, have prevented the ingress of plates and equant particles, while permitting the passage of minute fibres.

Asbestos nevertheless appears more actively fibrogenic than talc ; otherwise one would expect many more cases of pneumoconiosis to be reported from the rubber industry in which talc is widely used. This is understandable in view of the much higher proportion of fibres in asbestos ; but it is also possible that the different incidence of pneumoconiosis might be explained by variation in the dust concentrations in the asbestos and rubber industries. Complete surveys of the latter industry have not yet been made.

In the reported cases there is a remarkable histological similarity between asbestosis and talc pneumoconiosis which may be ascribed primarily to the physical form (acicular crystals) of the mineral. There are also chemical similarities between talc and the asbestos group of minerals, but as yet it is not clear how much weight should be attached to chemical factors in the causation of this disease. The presence of curious bodies, which resemble the well-known asbestosis bodies, in the lesions of talc pneumoconiosis, lends weight to the theory that the condition might be identical with asbestosis.

Summary and Conclusions

A man of 51 years of age died primarily from rheumatic endocarditis. He had worked thirty-seven years in a rubber tyre factory where he was exposed to a fair concentration of talc dust. Moderately advanced pneumoconiosis of both lungs was found at autopsy. This condition had been diagnosed during life and demonstrated radiographically.

A feature of the histology was the presence of " curious bodies " similar to asbestosis bodies associated with the pneumoconiotic lesion. Though there was much fibrosis of the lungs and abundant doubly refractile particles, an *x*-ray analysis of the lung ash suggested that there was less than 0·06 per cent. of free silica in the lung (dry weight).

A mineralogical description of the contents of the lung (mainly fibres of talc) and of talcs used at the factory to which the patient was exposed is added, and also a review of the literature relating to talc pneumoconiosis. The talc found in the lungs could have come from the Norwegian or Canadian varieties of the mineral. Both varieties are predominantly platy in form though each contains a proportion of fibres. The talc in the lungs consisted almost entirely of straight fibres, with a few curved fibres and shreds. This suggests that the respiratory passages acted as a selective filter, allowing the fibres to get into the lungs while rejecting the plates. The mineralogical observations establish clearly that fine grinding of talc gives rise to material having individual fibre form and perhaps suggests the presence of a previously unsuspected second cleavage parallel with the Z-direction.

It is likely that talc pneumoconiosis and asbestosis are similar diseases, though asbestos appears to be more actively fibrogenic than talc. The evidence suggests that talc pneumoconiosis is caused only by the fibrous varieties of talc.

Our thanks are due to Dr. E. M. Darmady who sent us the lungs, to Dr. J. S. Harper for the loan of radiographs and clinical notes, and to Dr. H. E. Harding for the chemical analyses of the lungs. We have also received much help from Dr. F. H. King. The radiographs were reproduced by the Welsh National Memorial Staff and the sections and microphotographs (figs. 1 to 7) by the Staff of the Department of Pathology of the Welsh National School of Medicine. Figs. 8, 9, and 10 were made by Mr. K. L. Goodall of the Factory Department. *X*-ray powder photographs were taken by Mr. H. J. Dothie of the Government Laboratory. Dr. Dunham's contribution is published with the permission of the Director of the Geological Survey and Museum.

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BOOK REVIEWS

Demonstrations of Physical Signs in Clinical Surgery. Part IV. By Hamilton Bailey, F.R.C.S., etc. 1948. Eleventh Edition. Bristol: John Wright and Sons, Pp. 122. Illustrated in colour. Price 8*s.* 6*d.*

This volume completes the present edition; it is hoped that in future the whole work will be printed in one volume, as splitting it up into parts seems unsatisfactory.

The value of this work lies to a large extent in the illustrations, and in this volume they are good. The written matter is more open to criticism but on the whole maintains the high standard of previous editions of this popular book. In the description of acute pancreatitis considerable stress is still laid on the Mydriatic test; few observers will put as much faith in it as the author does. No mention is made of the diastatic index in the urine, but this may have been excluded as not being a physical sign. In cases of acute osteomyelitis the clinician is advised to compare the size of the regional lymphatic glands with those on the unaffected limb. As far as we know, bones do not have any lymphatic drainage; so that if the lymphatic glands are inflamed in an early case the diagnosis is probably not acute osteomyelitis. Infection of lymphatic glands does not occur until the inflammation has spread outside the bone.

These are, however, minor criticisms of a book that can be recommended to student and doctor.

E. C. B. B.

Some Common Psychosomatic Manifestations. By J. Barrie Murray, M.A., M.D., M.R.C.P. 1949. Geoffrey Cumberlege: Oxford University Press. Pp. 101. Price 7*s.* 6*d.*

The book is largely devoted to a study of "effort syndrome" in a group of military psychiatric casualties. In it the author sets out to discuss the physical expressions of emotion as manifested in this disorder, which in his opinion is hysterical in type, and to evaluate the significance and relative incidence of associated symptoms. A chapter on the low back syndrome is included. Although the subject matter of this book is drawn from a military setting with its attendant artificially acute personal stresses, the numerical analysis of the physical manifestations of emotional disorder which it has been possible for the author to make in this particular group outweighs this slight disadvantage.

A vigorous plea for understanding by doctors of the psychiatric aspect of all physical disease and of the unfortunate consequences for the patient of unwisely repeated clinical examinations, over-treatment, and needless limitation of his activity, introduces a useful chapter on treatment. The book is a practical contribution of value to medical men in a field in which accurate evaluation of symptoms is at best difficult.

A. A. W.

BRITISH AND FOREIGN OFFICIAL PUBLICATIONS

The Interim Index of Industrial Production. Studies in Official Statistics, No. 1. London. H.M. Stationery Office. Pp. 52. Price 1*s*.

As a simple measure of the economic progress of the country in recent years, the Interim Index of Industrial Production performs a very useful service. The index, which is regularly published in the Monthly Digest of Statistics, shows how the level of industrial production, each month, compares with the average level attained in 1946. Taking 1946 as 100, the index of total production was 108 in 1947 (the year of the fuel crisis), 121 in 1948, and 130 in March 1949. An increase of 30 per cent. since 1946 is, it must be admitted, no mean achievement.

The Central Statistical Office, which is responsible for compiling the index, has recently produced an admirable account of the scope and main purposes of the index and of the methods used in selecting and combining the various component series. The explanation, though inevitably rather technical in parts, is clear and concise and is noticeably free from that heavy, official jargon in which the authors of Government publications so often seem to find it necessary to clothe their thoughts. The booklet is practically essential to anyone who uses the index of production. But it will also prove useful to anyone who is interested in the theoretical and practical problems involved in the construction of index numbers.

The term "industrial production" is used to include mining, all types of manufacturing, building and public utilities (gas, electricity, and water). Agriculture is not included because of the fluctuations in harvest yields and the difficulties of obtaining any reliable measure of the output attributable to any given month. Other activities deliberately excluded from the index are transport, distribution, commerce, and public and private services. It is important to remember that, if all these activities were included, there would probably be a different story to tell.

There is a separate section on building with some interesting figures about the construction of new houses. Ingenious methods are employed to ensure that the index reflects not only the number of houses completed each month but also the work done on houses which are not completed until some time later.

A comparison is also made of the levels of industrial production in the years 1935–38 and 1946. Total industrial production was lower in 1935 but higher in 1937 than in 1946—the estimates of the changes depending on the "weights" used for combining the different industries. *M. G.*

ABSTRACTS

(This section of the JOURNAL *is published in collaboration with the two abstracting Journals, Abstracts of World Medicine, and Abstracts of World Surgery, Obstetrics, and Gynæcology, published by the British Medical Association. The abstracts are divided into the following sections: toxicology; industrial physiology; industrial lung disease; industrial skin diseases; accidents and orthopædic surgery; industrial ophthalmology; environment; general. Not all sections will necessarily be represented in any one issue.)*

TOXICOLOGY

The Lead Content of Blood and Cerebrospinal Fluid in Experimental Lead Poisoning. (Der Bleigehalt im Blut und Liquor cerebrospinalis bei experimenteller Bleivergiftung.) STRAUBE, G. (1948). *Klin. Wschr.*, **26,** 595.

The blood and cerebrospinal fluid having been first examined and found to be free from lead, three lambs were given lead acetate in increasing doses. Blood was taken from the jugular veins and cerebrospinal fluid by suboccipital puncture, under "evipan" anæsthesia. The first symptoms to appear were weakness of the hind legs and then of the forelegs; scanty stools, failing appetite, general partial paralysis, and tetanic spasms were observed later. This does not correspond with the effects observed in man. The cerebrospinal fluid remained lead-free until the concentration of lead in the blood had reached a level of 20 to 30 μg. per 100 ml., when the concentration in cerebrospinal fluid was found to be between 6 and 9 μg. per ml. This occurred in all 3 animals. The exact proportion of lead in the cerebrospinal fluid was not determined because the quantity of the fluid obtainable was too small. There certainly exists a parallel between the lead content of the blood and that of the cerebrospinal fluid, although the latter lags behind and in no instance was found to overtake or even approach the figure for blood. This lesser content in the cerebrospinal fluid is more obvious as the concentration in the blood is increased, although the curves maintain simultaneous rises or falls. Two of the animals, in a state of lead poisoning, died from an overdose of narcotic. There was no trace of lead in the brain of either, but a large quantity was found in the long bones and a moderate amount in the exsanguinated liver. Permeability was tested by Walter's method in two of the lambs. Before administration of lead the permeability quotients were 5·80 and 5·49. After administration of lead had started and until the first appearance of symptoms there was a slight fall in the quotient, which may not be significant because the normal limits of permeability in this animal are not known. When the lead concentration in the blood rose to 110 μg. per 100 ml. and in the cerebrospinal fluid to 22 μg. per 100 ml. the permeability quotient rose to 12, possibly by a compensatory defence reaction. Further research is needed to confirm and explain this result of one single observation. *M. A. Dobbin Crawford.*

Comparative Evaluation of Methods Employed to Express the Degree of Toxicity of a Compound. DEICHMANN, W. B., and MERGARD, E. G. (1948). *J. industr. Hyg.*, **30**, 373.

Clinical Features of Intoxication with Barium Salts. (In Russian.) KAZAKEVICH, M. A. (1948). *Klin. Med., Mosk.*, **26**, No. 11, 56.

Five cases of acute intoxication due to barium salts are described. The author distinguishes three stages of intoxication. (1) An early stage beginning within 1 hour to 2 hours of ingestion of the poison and characterized by symptoms of gastro-enteritis, symptoms and signs of cardiovascular disturbance (pain in the chest, facial pallor or cyanosis, arrhythmias, smallness of pulse), and changes in the blood (leucocytosis, lymphopenia, a shift to the left in the white cell count, and increase in erythrocyte sedimentation rate). Signs of encephalopathy also begin to appear (vertigo, ataxia, muscle weakness, sweating, salivation). Death may follow quickly, or there may be rapid recovery or a change to the second stage. (2) The encephalopathy becomes more pronounced, with stress on disturbances of the cerebello-vestibular apparatus, visual or auditory defect, and emotional lability. (3) As sequelæ persistent neurological or psychic changes may occur. The author considers that the early symptoms may be conditioned by a central effect—for example, on the vagal nuclei. *S. S. B. Gilder.*

Experimental Argyrosis. IV. Morphologic Changes in the Experimental Animal. OLCOTT, C. T. (1948). *Amer. J. Path.*, **24**, 813.

Rats were given 1 in 1,000 solutions of silver by mouth throughout life; in some cases this resulted in unexplained left ventricular hypertrophy. At necropsy most of the organs were pigmented and silver was found in reticulo-endothelial elements in lymph nodes, liver, and splenic pulp, in relation to blood vessels, and in glomerular capillary basement membranes. Silver is absorbed in the small and large intestine. The sites and mode of deposition of ingested silver are contrasted with those obtained by the standard silver-impregnation techniques, and the lesions are compared with those found in human argyrosis; the changes are essentially similar in man and the rat. *R. C. B. Pugh.*

The Relation of Particle Size of Uranium Dioxide Dust to Toxicity Following Inhalation by Animals. Preliminary Report. WILSON, H. B., SYLVESTER, G. E., LASKIN, S., LABELLE, C. W., and STOKINGER, H. E. (1948). *J. industr. Hyg.*, **3**, 319.

One of the authors (LaBelle) found that when particles of uranium dioxide were injected intratracheally into rats their toxicity increased sharply as the particle size decreased below 1 μ. The present study was designed to ascertain whether a corresponding change of toxicity occurs when particles of UO_2 dust of different sizes are inhaled instead of being injected tracheally. The dust feed employed was an atomizing unit suspended in a gallon (4·5 litres) jar containing UO_2 dust of the graded particle size. The suspension was stirred continuously by a mechanical stirrer, and aqueous suspensions of UO_2 were atomized from it by a current of dry nitrogen so as to produce essentially dry aerosols in the exposure chamber. The animals were exposed in a 4-foot (120 cm.) Monel metal cube, air being exhausted through four ports near the chamber bottom. In the preparation of the smaller particle size 3 kg. of whole UO_2 were mixed with 1,800 ml. of water and ground for 3 days in a ball mill with steel balls. The mixture was stirred with normal hydrochloric acid in order to remove iron, and the residue washed repeatedly with 5% sodium chloride and then with water. Suspensions of the final residues were allowed to stand for 16 hours and the top layers siphoned off. The final siphonates contained particles averaging 1·25 μ, and when dispersed into the exposure atmosphere by the atomizing feed they consistently yielded dust particles of 0·45 μ. The UO_2 particles of larger size were prepared by a different method.

In each of two studies 16 rabbits and 24 rats were exposed for a total of 29 exposure days and 191 exposure hours. In order to estimate the UO_2 in the air, filter-paper-dust samples were taken each day, the air-flow rate being 12·5 litres per minute. The average UO_2 concentration was about 80 mg. per cubic metre. At least one sample was taken each day for particle-size determination by the modified cascade impactor method. The mass median particle size was 0·45 μ in the small-particle tests, and greater than 1 μ in the other tests, Daily measurements of the blood non-protein nitrogen, the urinary protein, and the amino-acid nitrogen ratios showed that in the rabbits treated with small particles there were significant increases at the end of the first week, and peaks well above the normal at the end of the second week. Thereafter the blood non-protein nitrogen dropped rapidly to normal. In the large particle tests the rates of increase and the magnitude of the peaks were much smaller. In the rat tests 2 animals were killed each week, and the data for lung damage and weight indicated significant lung irritation, the small particles causing severe damage near the second week of experiment, while the large particles caused only slight irritation during the first three weeks. Analyses of the tissues showed that the retention of uranium in the lungs of rabbits and rats was approximately 1,000 times greater than its deposition in either kidney or bone. About six times as much uranium was retained in the lungs of rabbits inhaling small particles as in those inhaling large particles, while in the lungs of rats the excess was 2·5 times as great. *H. M. Vernon.*

Hygienic Characteristics of the Production of Hard Alloys. (In Russian.) PARKHOMENKO, G. M. (1948). *Gigiena*, No. 9, 11.

Investigations were conducted in plants and industrial establishments where workmen handle the ores of wolfram, titanium, and cobalt and carbides of these metals. The latter in the finely dispersed state may form a stable aerosol. The average size of metal dust particles was 1 to 4 μ, and the range of minimal and maximal concentration (in mg. per cubic metre) was 5·8 to 63·0 and 19·1 to 320·0. The cobalt-containing dust was more toxic than other types of hard-alloy dust. The more readily soluble cobalt salts had a more pronounced toxic effect than the less soluble salts. The following symptoms of chronic cobalt poisoning were seen: vomiting, nausea, pain in the epigastrium, allergic skin changes, and enlarged liver, albumin and erythrocytes were found in the urine and there were catarrhal symptoms in the upper respiratory passages. The most noticeable effects of prolonged contact with the wolfram (tungsten) dust were irritation of the mucous membrane of the upper respiratory tract and irritation and hyperæmia of the conjunctiva. The dust from a hard alloy containing cobalt had no specific effect. In many stages of the industrial processes involving the use of the above metals

or their alloys carbon monoxide fumes are generated. The hygienic measures, mainly improvement in technological processes so as to reduce or eliminate dust formation and generation of dangerous fumes, are discussed; and regular medical examination of workers together with inspection of the premises is advocated as a means of detecting at an early stage the injurious effect of working with hard alloys. *H. P. Fox.*

Two Chlorinated Tertiary Amines (Diethyl-β-Chloroethyl Amine and Dimethyl-β-Chloroethyl Amine). Toxicity in Industrial Use. WATROUS, R. M., MARTINS, J. K., and SCHULTZ, H. N. (1948). *Industr. Med.*, **17**, 237.

Tertiary alkalyl amines have become industrially important because of their use as side-chains in the manufacture of synthetic drugs such as mepacrine (atebrin), chloroquine, "amethone," and several antihistamine drugs. The two amines discussed may be called for short DEA and DMA. Both have vesicant properties. Observations of 4 men exposed to DMA at levels between 50 and 500 μg. per litre indicate that it can cause prolonged dilatation of the pupil, nausea, and vomiting without any demonstrable effect on the circulatory system or destruction of leucocytes. At levels of 5 mg. per litre the skin was irritated and became necrotic.

Ordinary tests for tertiary amines were found to be unsuitable for determining small amounts of DMA. A colour reaction with 0·1% picric acid in chloroform was developed and found to be reliable in detecting as little as 1 to 2 μg. per litre. This test is fully described. The authors suggest that toxic symptoms can occur if air contaminated with DMA at levels above 25 μg. per litre is breathed for 8 hours. The only toxic effect observed from DEA occurred in a man working in the development laboratory. It had a pronounced irritant effect on the eyes and mucous membranes of the nose, and caused a mild pulmonary œdema. Because of this incident great care was used in planning its commercial use and no further cases occurred. *R. S. F. Schilling.*

Experimental Studies on Intoxication with Adipic Nitrile, NC-$(CH_2)_4$-CN. (Ricerche sperimentali sull'intossicazione da nitrile adipico: NC-$(CH_2)_4$-CN). CERESA, C. (1948). *Med. d. Lavoro*, **39**, 274.

In an earlier paper the author studied the blood changes seen in nylon workers. These exhibited slight hyperchromic anæmia with frequent leucopenia and monocytosis. The anæmia was of hæmolytic type with a positive indirect and a negative direct van den Bergh reaction. The serum bilirubin level was raised. These blood changes were attributed to the toxic action of the solvents used, and particularly to the nitrile of adipic acid. Hexamethylene diamine was also incriminated. As the nylon industry is growing, it seemed appropriate to carry out detailed examination of the materials used. The nitrile of adipic acid was administered to guinea-pigs by the subcutaneous and oral routes and also by rubbing into the skin; it was not found possible to administer it by inhalation. The toxicity of the compound is attributed particularly to the CN group.

When injected subcutaneously into 4 animals, in doses varying from 0·4 to 0·1 ml., death occurred within 8 to 15 hours. Three other animals had one drop by the mouth on the first day and two drops daily for two more days. These died in a few hours, exhibiting spastic contractions, stretching of the limbs, and dilatation of the pupils. The periods of spasm were interrupted by long pauses during which the animals were curled up and exhibited some dyspnœa. At necropsy the liver and meninges were found to be congested. Microscopical investigation also demonstrated congestion, particularly in the central nervous system. These findings were consistent with the effects of acute poisoning.

To observe the results of chronic poisoning the material was rubbed into the skin on alternate days for a month. After a few applications the animals began to lose weight and energy, and some died after 3 or 4 doses, while others survived as many as 16 doses. Death occurred insidiously from inertia and malnutrition due to refusal of food. No contractions or paralyses were noted. When death seemed imminent blood samples were taken, and at necropsy, the marrow and other tissues were examined. Biochemical investigation showed a constantly negative direct van den Bergh reaction and indirect positive reactions in 7 out of 9 cases. The calcium of the blood was diminished but the bone calcium unchanged. Chloride levels were within normal limits. Post-mortem examination revealed nothing of note apart from congestion, but histologically there were slight fatty degeneration of the liver, swelling of the convoluted tubules of the kidney, and marked hæmosiderosis in the spleen. Hæmatological examination showed marked hyperchromic anæmia due to hæmolysis and associated with leucopenia and monocytosis. These findings agree with those noted by the author in nylon workers. *G. C. Pether.*

The Toxicity of Dimethyl-, Diethyl-, and Di*iso*propyl Fluorophosphate Vapours. SILVER, S. D. (1948). *J. industr. Hyg.*, **30**, 307.

Investigations have disclosed the usefulness of the derivatives of fluorophosphoric acid in the treatment of some physical disorders. The present paper gives information concerning the vapour hazards connected with the handling of these compounds. The substances investigated were dimethyl fluorophosphate $(CH_2O)_2$POF, and the corresponding diethyl and di*iso*propyl fluorophosphates. They were volatilized from a bubbler by means of a stream of dry nitrogen, the vapour passing into a 386-litre chamber, which was operated by the constant-flow method. Twenty mice were exposed for 10 minutes in each run, and deaths were recorded for 10 days after exposure. The concentrations investigated ranged from 0·1 mg. per litre to 0·32 mg. per litre in the case of the dimethyl compound, from 0·17 to 0·45 mg. for the diethyl compound, and from 0·42 to 0·64 mg. for the di*iso*propyl compound. The median lethal concentrations were calculated to be 0·29 mg. per litre for the diethyl compound, 0·50 mg. for the diethyl compound, and 0·60 mg. for the di*iso*propyl compound. The diethyl compound caused rapid pawing of the nose, convulsions, and heavy breathing, often followed by death. The higher concentrations caused lacrimation, though no eye symptoms were noted during the gassing, but only 1 to 6 hours later.

Eye effects were investigated in rabbits by the use of modified eye cups. The di*iso*propyl compound was found to be effective at much lower concentrations than the dimethyl and diethyl compounds, and maximum pupillary constriction was attained at a concentration of 0·092 mg. per litre, while 6 to 8 mg. per litre of the dimethyl and diethyl compounds were necessary. The duration of pupillary constriction was almost 100 times as great for the di*iso*propyl compound as for comparable concentration-time exposures of the other two compounds.

In experiments on eye effects in human beings a cubical glass-walled chamber with a capacity of 441 litres was used. The front had a pair of moulded rubber eyepieces so shaped as to fit practically any face ; this permitted the subject to expose only his eyes to the compound, which was placed in a dish on a hot plate, and was distributed by an electric fan. The subjects were 6 men, and it was found that 20 to 30 minutes after a 3-minute exposure to 0·10 mg. per litre of the di*iso*propyl compound the pupils generally reached maximum constriction. This constriction remained to some extent for a week. Men exposed for 6 minutes showed similar, but somewhat more severe, effects. At night vision was so bad for the first 48 hours that it was dificult to see in artificial light, and a sudden increase of illumination was blinding. The eyes were painful if the men read during the first 48 hours. The median detectable concentrations by smell were found to be 0·18 mg. per litre for the dimethyl compound, 0·15 mg. for the diethyl compound, and 0·36 mg. for the di*iso*propyl compound.

H. M. Vernon.

Absorption and Excretion of Carbon Disulphide in Man. (O vstřebávání a vylučování sirouhlíku u člověka). TEISINGER, J., and SOUČEK, B. (1948). *Cas. Lék. čes.*, **87**, 933.

The authors performed experiments on 9 subjects, who inhaled a mixture of carbon disulphide (CS_2) and air (of known concentration) for 1 to 4 hours. The inhaled and expired air, blood, and urine were tested for CS_2 content during and after the experiment until CS_2 disappeared from the blood and urine. The mixture of CS_2 and air was inhaled from a special container and the expired air was introduced into a gas-meter. The concentration of CS_2 in the air was kept at constant level (variation did not exceed ± 6 µg. per litre). The estimations were made every 15 minutes by the diethylamine and copper method. The doses used were 58 to 105 µg. per litre. The subjects experienced no discomfort except for a slight occasional headache. Absorption in the first 15 minutes averaged 80% ; after 45 minutes and until the end of the experiment it was almost constant at 40%. The blood level increased slowly and reached a maximum in about 2 hours. On cessation of inhalation CS_2 disappeared from the blood in about 2 hours. Air/blood equilibrium was established in 90 to 120 minutes. The coefficient of distribution of CS_2 in blood/air varied between 0·9 and 3·9 with an average of 2·3. The blood level of CS_2 at equilibrium was about 150 to 280 µg. per litre.

Excretion of CS_2 through the lung amounted to 6%, so that on the average 95% of CS_2 was retained in the tissues, where it was detoxified. These experiments confirmed the results of McKee and co-workers. Excretion in the urine was insignificant. CS_2 appeared in the urine about 1½ hours after inhalation started ; 24 to 30 hours after cessation of inhalation no CS_2 could be detected in the urine, and the amount of CS_2 excreted in the urine was about 0·06% of the total retained in the body. No analysis of the fæces was made.

In a second experiment 12 workers, who had already been exposed for 12 hours to CS_2 inhalation in a viscose silk factory, were tested. The concentration of CS_2 in the air was 108 to 142 µg. per litre or 185 to 217 µg. per litre. The majority of these workers complained of impotence, loss of weight, malaise, and restless sleep. These persons retained, after additional inhalation of CS_2, appreciably less than non-exposed persons. After ¾ to 1 hour their bodies were already saturated and then excreted appreciable amounts of CS_2 in the urine ; the maximum concentration found was 4 mg. per litre of urine.

J. Ungar.

Carbon Disulphide Poisoning in an Artificial Silk Factory. (Otravy sirouhlíkem v továrně na viskosové hedvábí.) REJSEK, K., PETRÁN, V., TEISINGER, J., and SOUČEK, B. (1948). *Cas. Lék. čes.*, **87**, 937.

Thirty-three workers in a viscose silk factory were examined ; 6 had to be sent for hospital treatment and 3 were sent to a mental hospital with symptoms of schizophrenia or paranoia. The concentration of carbon disulphide in the air varied from 70 to 300 µg. per litre and fell after improved ventilation to 50 to 100 µg. per litre. Improved ventilation did not prevent the occurrence of serious poisoning. The clinical picture was characterized by vegetative neurosis and neurological and psychiatric signs. No hæmatological or other abnormal signs were found on physical examination. Two cases are recorded, one with a polyneuritic syndrome and damage to the extrapyramidal system (Quarelli's syndrome), and the other with hallucinatory manifestations. The level of carbon disulphide in the blood was raised in some of the workers to 47 µg. per 100 ml., and in the urine to 20 to 200 µg. per litre ; the values depended on the carbon disulphide concentration in the inhaled air and on the duration of exposure. The authors conclude that an increased blood level is no indication of poisoning but only of exposure. It is of greater importance to establish the degree of tissue saturation with carbon disulphide.

J. Ungar.

Brain Volume, Diameter of the Blood-vessels in the Pia Mater, and Intracranial Pressure in Acute Carbon Monoxide Poisoning. (In English.) SJOSTRAND, T. (1948). *Acta physiol. scand.*, **15**, 351.

The cause of headache after carbon monoxide poisoning was investigated by studying the effects of the gas on the brain volume, diameter of the blood vessels in the pia mater, and intracranial pressure. A glass window was mounted in the skull of cats under light anæsthesia, and carbon monoxide administered through the lungs. Measurements were made of the blood vessels and changes in brain volume with an "ultropak" microscope. The intracranial pressure was measured by a water manometer connected to a cannula fastened to the window. During absorption of carbon monoxide the diameter of the blood vessels, particularly arteries and capillaries, in the pia mater increased. The diameter of the veins was, however, only slightly changed. After the cessation of carbon monoxide administration the brain volume and the diameter of the blood vessels slowly decreased to nearly their original sizes. The intracranial pressure, which was greatly increased during exposure decreased rapidly upon the cessation of carbon monoxide administration and fell to considerably below the initial level. It is suggested that the swelling of the brain and pressure rise in the skull cavity produces the sensation of "pressure in the head." After exposure, when the intracranial pressure drops, the remaining dilatation of the arteries may still influence the blood supply to the brain, with consequent pain.

G. F. Somers.

INDUSTRIAL PHYSIOLOGY

Experimental Investigations of the Influence of Vibration on the Human Organism. (In Russian.) KRIZHANSKAYA, D. A. (1948). *Gigiena*, No. 10, 1.

The effect of mild mechanical vibrations most frequently met with in town transport on the autonomic nervous system was studied. Tests were made on 25 healthy volunteers (mostly women), aged 20 to 25, subjected to mild horizontal vibrations for 10 to 15 minutes, their frequency varying within 2 and 10 Hz. with an amplitude of 0·3 to 0·6 cm. Three types of reaction were noted: (*a*) rapid autonomic reaction followed quickly by complete adaptation to vibrations; no complaints of discomfort caused by vibrations were made by experimental subjects in this group; (*b*) a moderate reaction with practically no subjective complaints; and (*c*) an almost entire absence of autonomic reaction with pronounced unpleasant subjective sensations. During menstruation persons in group (*b*) showed an increased sensitivity to vibrations and a marked lack of adaptation—for example, nausea as seen under normal conditions in group (*c*). *H. P. Fox.*

Pilot Metabolism and Respiratory Activity During Varied Flight Tasks. COREY, E. L. (1948). *J. appl. Physiol.*, **1**, 35.

The metabolic rate of pilots was measured by means of a standard clinical spirometer. Eight trained pilots, having varying flying experience, and two non-aviators were observed in a Link trainer while flying on various manœuvres, and three of the pilots while flying a Piper J-3 aircraft (16 flights).

Pilot metabolism in the Link trainer was found to increase with increasing complexity of the flight task, and such increases were greater in the inexperienced than the experienced pilots (86 experiments). In non-pilots the increase was of up to 50% and in pilots of up to 30% above resting values. The increases were often much greater than would be expected from the physical work being done, and it is concluded that they represent a general increase in muscular tension. Respiratory rate (274 experiments) changed in the same direction but the correlation with flight experience was not so close. Changes were of from 10 to 16 respirations per minute above the resting rate. In the aircraft, metabolism and respiratory rate showed the same qualitative relation to task complexity, but the changes were greater, the student pilots' metabolism increasing by 88% during the execution of a rectangular flying pattern. Direct comparison with the results from the Link trainer is impossible, since the tasks were different and the turbulence of the air cannot be assessed. The difference is thought to be due mainly to the existence of danger involved in flying the aircraft which is absent when the Link trainer is used. *D. McK. Kerslake.*

Arterial Blood Cases During Pressure Breathing at Simulated High Altitudes. TAYLOR, C. B., MARBARGER, J. P., and POWER, M. H. (1948). *J. appl. Physiol.*, **1**, 45.

Gas content and *p*H of arterial blood were measured at simulated high altitudes in young men during continuous pressure breathing: (*a*) with counter-pressure to the trunk (but an inflatable jacket); (*b*) without counter-pressure.

At 46,000 ft. (13,800 m.), oxygen being breathed at the ambient pressure, the mean oxygen saturation for 3 samples was 67·2%. With 15 mm. Hg positive pressure and counter-pressure the mean value for 9 samples was 77·0%. The mean value for 12 samples, without counter-pressure, was 78·2%. At 46,000 ft., with positive pressures of 29 to 34 mm. Hg and counter-pressure, the oxygen saturation was 88·0 to 99·6% and at 50,000 ft. (15,000 m.) with 32 to 33 mm. positive pressure, it was 75·9 to 77·0%. Millikan oximeter values were found to be within ±6% of the gasometric values. At 46,000 ft. and 15 mm. Hg positive pressure the mean carbon-dioxide content of 21 samples was 46·1 volumes per 100 ml. plasma, range 42·9 to 49·9. The mean *p*H was 7·45, range 7·40 to 7·52. The sum of the calculated arterial carbon dioxide and oxygen tensions, plus the alveolar water vapour tension, closely approximated to the sum of the barometric pressure and the breathing pressure.

The results suggested that (1) no significant difference existed between the data collected with and without counter-pressure; (2) the arterial oxygen and carbon dioxide partial pressures attain equality with their alveolar partial pressures, as in normal respiration at high altitudes; (3) the gain in altitude tolerance is about that expected from the increased oxygen pressure supplied, as far as oxygen is concerned; (4) the oxygen saturation at 46,000 ft. and 15 mm. Hg positive pressure is insufficient to maintain physiological efficiency. *K. E. Cooper.*

Iontophoresis with Acetyl-*beta*-methyl-choline and Blood Flow through the Hand at Low Environmental Temperatures. MACHT, M. B., and BADER, M. E. (1948). *J. appl. Physiol.*, **1**, 205.

The blood supply to the hand was measured by means of the venous occlusion plethysmograph, in lightly dressed subjects sitting at a room temperature of 15° C. The fluid in the plethysmograph was acetyl-β-methyl-choline (ABMC) at between 8° and 15° C. The metal of the plethysmograph being used as the positive electrode and a negative electrode being applied to the back, ABMC was introduced into the hand by iontophoresis, while flow measurements were in progress. In 5 of 6 subjects there was a significant increase in the blood flow through the hand, where previously there had been intense vasoconstriction as the result of cold. No increase in blood flow was found in experiments: (*a*) in which there was no iontophoresis, or (*b*) in which saline was substituted for ABMC. After ABMC iontophoresis there was "almost invariably" marked and persistent sweating on the dorsum of the hand, but none on the palmar surface. *W. S. S. Ladell.*

Indirect Peripheral Vasodilatation Produced by the Warming of Various Body Areas. BADER, M. E., and MACHT, M. B. (1948). *J. appl. Physiol.*, **1**, 215.

Skin temperature, rectal temperature, and blood flow through the hand were measured on two subjects: (*a*) in air at 15° C. and (*b*) in air at 23·5° C. The changes induced by the local application of radiant heat to the face, the chest, or the foot and lower leg were observed. At 15° C. changes were seen only when the face was warmed; after 80 minutes when the skin of the face was warmed to 42° to 44° C. the average rise in the skin temperature of the hand was 9·8° C. and there was a six-fold increase in blood flow through the hand; skin temperature elsewhere, and the rectal temperature, were practically unaltered. At 23·5° C. warming of either chest or face resulted in significant increases in skin temperature and blood flow of the hand; toe temperature also rose. No other changes were noted elsewhere. The authors discuss their results with particular reference to similar work by others in this field. *W. S. S. Ladell.*

Regional Differences in the Basal and Maximal Rates of Blood Flow in the Skin. HERTZMAN, A. B., and RANDALL, W. C. (1948). *J. appl. Physiol.*, **1**, 234.

There is good correlation between the volume pulse, measured with the photoelectric plethysmograph, and the blood flow in the finger. By use of this correlation the cutaneous blood flow was estimated on each of two subjects in 22 different skin areas, and the total cutaneous blood flow calculated from the sum of the various estimations. At room temperatures of 25° to 27° C. when, the authors considered, flow was basal the figure obtained in this way was of the same order, though somewhat higher, than that obtained indirectly from thermal data. When maximal flow was induced by iontophoresis of a vasodilator or by heat the flow estimated by this method was higher than that found in other experiments by volume plethysmography with similar vasodilation. There was a high basal flow through the skin of the head and through the palmar and plantar surfaces, and a low flow through the trunk, leg, and thigh skin ; flow through the forearm skin was approximately equal to the mean cutaneous flow. Regional differences were the same at maximal rates of flow as under basal conditions. The authors discuss the validity of their method, and conclude that volume pulse records may be used to estimate blood flow with sufficient accuracy for the study of vascular reactions in the skin. *W. S. S. Ladell.*

Effect of Meals on Visual Performance and Fatigue. SIMONSON, E., BROZEK, J., and KEYS, A. (1948). *J. appl. Physiol.*, **1**, 270.

The effect of no meal, of a standard meal, or of a high fat or high carbohydrate meal of about 1,300 calories (lunch), on the visual performance and fatigue in 6 young men who had been full-time experimental subjects in a nutritional investigation for the year preceding the visual tests, was examined. The subjects carried out an inspection task on a conveyor belt for 2 hours. The work test began 30 minutes after lunch and was evaluated over 6-minute periods at 5, 60, and 110 minutes from the start. The blinking rate was simultaneously determined. Visual tests were carried out immediately before and after the task. The results showed that no one type of meal was optimal for all functions. Thus, performance criteria were poorest after the high carbohydrate meal but the subjective discomfort was least. The standard meal (carbohydrate calories 50%, protein calories 12%, fat 38%) or the high fat meal (fat calories 83%, carbohydrate 14%, and protein 3%) was preferable for the majority of the visual functions. *C. C. N. Vass.*

Influence of Hæmorrhage, Albumin Infusion, Bed Rest, and Exposure to Cold on Performance in the Heat. SPEALMAN, C. R., BIXBY, E. W., WILEY, J. L., and NEWTON, M. (1948). *J. appl. Physiol.*, **1**, 242.

To test the hypothesis that the improvement in performance during successive exposures to heat is due mainly to an increase in blood volume, the blood volume of male subjects was changed and the effect on their performance in the heat noted.

Changes in performance could not have been due to alterations in the hæmoglobin concentration, as deterioration was observed both after a rise and after a fall in the latter, but in each case consideration of the changes in both hæmoglobin and plasma protein concentrations suggested that when performance had deteriorated there had been a fall in the blood volume. The authors state that : " If our results are interpreted correctly . . . small changes in blood volume (less than 5% in some instances) affect rather greatly the ability of partially acclimatized individuals to perform physical tasks under warm conditions." They cite as further evidence a statistically significant association between hæmoglobin concentration and performance, good performances being associated with low hæmoglobin value and *vice versa*, the assumption being that blood volume and hæmoglobin concentration are inversely proportional. None of the procedures affected the rise in rectal temperature or sweat rate during exercise. [The Medical Research Council team on heat physiology found that changes in sweat rate and rectal temperature were important indications of acclimatization. They also showed that the greater part of the increase in blood volume during acclimatization occurred during the first day of exposure to the heat, whereas performance continued to improve for some days afterwards.] *W. S. S. Ladell.*

Heart Rate in Recovery from Severe Exercise. HERXHEIMER, H. (1948). *J. appl. Physiol.*, **1**, 279.

The delayed recovery of the resting pulse rate after severe exercise has been attributed to vasodilatation. This paper records an attempt to determine the extent of the vasodilatation and to ascertain whether it could be prevented by bandaging the limbs. The subjects were 4 trained boy cyclists. The initial pulse rate was counted after a 10-minute rest in the horizontal position. Subsequently the subject was exercised on a bicycle ergometer adjusted so that severe dyspnœa set in during the third minute and continued to the end of the fifth minute. The oxygen consumption was computed to be between 3,500 and 3,800 per minute during the dyspnœic period ; in two experiments the initial oxygen consumption was re-attained, with the subject seated, after 43 and 57 minutes. In half the experiments elastic bandages were applied immediately after the exercise, and the pulse rate was taken with the subject in the horizontal position until a basal value was reached, when the bandages were removed and the pulse rate counted for a further 15 minutes. Limb volumes were also measured, a crude plethysmograph being used. In all but two experiments the pulse rate reached its basal value more quickly when the limbs were bandaged. The leg volume increased in all experiments after exercise to an average of 275.
C. C. N. Vass.

Effect of Climate on the Blood Pressure in Acclimatized Subjects. FOURMAN, L. P. R. (1948). *Trans. R. Soc. trop. Med. Hyg.*, **42**, 299.

Sailing from the Red Sea to the Mediterranean there is a sudden fall in temperature and humidity. Observations were made on the effect of this on the blood pressure. Forty-five subjects and 3 patients with hypertension were studied under resting conditions. There was no significant change in the blood pressure when the relative humidity diminished by about 20%.—(From the author's summary.)

Clinical Effects of Noise and Mechanical Vibrations of a Turbo-jet Engine on Man. FINKLE, A. L., and POPPEN, J. R. (1948). *J. appl. Physiol.*, **1**, 183.

The authors describe experiments to determine the immediate and delayed results of exposing men to vibrations caused by running jet aircraft engines at high speed. Until plugs and helmets were used audiometry showed a sharp temporary decrease in auditory acuity in the " conversational frequency range " of 512 to 4,096 cycles per second. *Roland Winfield.*

INDUSTRIAL LUNG DISEASE

Stannosis. (Stannosis.) BARTÁK, F., TOMEČKA, M., and TOMÍČEK, O. (1948). *Čas. Lék. čes.*, **87**, 915.

The authors describe stannosis pulmonum, due to inhalation of dust of tin oxide (SnO_2). An unusual chest radiograph was first seen in 1939 in a man of 49 who had suffered from asthma from puberty and who had been working for 18 years in a furnace in which tin was burned to tin oxide. Both lungs were diffusely and densely infiltrated with fine, hard shadows, which were more marked in the lateral parts. Broncho-vascular markings were not increased. The density of the shadows suggested foreign bodies. Similar radiographs were obtained in 6 out of 16 other persons handling tin oxide; 5 of the 6 had been burning tin for from 2 to 25 years; the sixth for only 6 months continuously. In the remaining 10, who were employed largely in packing tin oxide where less dust was produced, no changes were observed.

The first patient died later from carcinoma of the stomach. Nothing was found at necropsy to correspond with the *x*-ray appearances, but histological examination showed a black-brown pigment in the thickened interalveolar septa, and also in parts of the thickened pleura and in the adventitia of the peribronchial and subpleural vessels. There was atrophic emphysema, and the pigment was found even in the finer alveolar septi, the particles measuring a fraction of a micron. There was macrophagic reaction especially in the pleura and round the bronchi. Chemical analysis of the ash of various organs revealed the following percentages of weight of tin: lung 20·37, regional lymph nodes 2·14, liver 0·60, and spleen 0·30; there was none in the brain. Micro-incineration of histological sections 10 μ thick showed the alveoli outlined by a fine granular material which was denser round the bronchi. Half the pigment visible in ordinary sections, presumably local, had disappeared. There was much less pigment in the lymph nodes. Similar micro-incineration was carried out in rabbits and guinea-pigs that had received powdered tin oxide by injection into the circulation and into the peritoneal cavity. The density of the material to *x* rays was investigated by rubbing it in petroleum jelly on the skin of a normal man, or by taking radiographs in rabbits receiving intravenous injections of 0·2 g. of SnO_2, which showed that it was radio-opaque in minute amounts.

H. Pollak.

Delayed Chemical Pneumonitis in Workers Exposed to Beryllium Compounds. HARDY, H. L. (1948). *Amer. Rev. Tuberc.*, **57**, 547.

This is a report on 36 cases of delayed chemical pneumonitis which occurred among 1,400 workers exposed to a fluorescent powder containing the silicates of zinc, manganese, and beryllium. The radiological and pathological appearances in these cases did not correspond with those due to the effects of zinc, manganese, or silica. Beryllium was the only common denominator and was accepted as the cause. Possible predisposing factors in 7 cases were chronic respiratory infections; in 3 cases war fatigue; in 9 cases the illness followed pregnancy. The duration of exposure varied from 8 months to 8 years, and the onset of symptoms from 1 month to 4 years from the date of the last exposure.

Delayed chemical pneumonitis is a long, severe illness. The symptoms appear gradually. In 13 cases these were severe: weight loss 40 lb. in the first year of illness; dyspnœa with a respiratory rate up to 40 per minute; and anorexia with nausea and vomiting. In 14 cases symptoms were moderate: weight loss 25 lb.; respiratory rate 30 per minute; and anorexia and vomiting. In 5 cases they were mild: weight loss 10 lb.; dyspnœa only on exertion. In 4 cases there were no symptoms. Of the patients who had symptoms 6 died, 23 remained functionally disabled, and 3 were convalescent but able to work after 18 months of illness.

The differential diagnosis is discussed. In silicosis the illness is not so severe except towards the end, there are not the same early widespread changes in the lungs, and the lung ash yields abnormal quantities of silica. In fatal cases of delayed chemical pneumonitis the lung ash contains only normal quantities of silica. In one case where the illness had been short and severe there were marked emphysema at the apices and extensive cellular replacement of the lung tissue; in another case, in which the patient lived 1½ years longer, there was profuse pulmonary granulomatosis with giant cells and hyaline fibrosis. Three "neighbour" cases are also recorded: 2 of these patients lived close to the luminizing factory, while the other had nursed her daughter through a fatal attack of this illness. *M. A. Dobbin Crawford.*

The Pneumonitis and Granulomatosis Peculiar to Beryllium Workers. DUTRA, F. R. (1948). *Amer. J. Path.*, **24**, 1137.

In acute cases the pneumonitis is characterized by a mononuclear exudation; in chronic cases there are fibrosis, emphysema, and nodules, which are considered specific. The nodules begin in organizing intra-alveolar necrotic fibrinoid exudation, and in the fibrosis of inflamed septa. Many contain giant cells of the Langhans type. Conchoidal bodies occur as in Boeck's sarcoidosis. *D. M. Pryce.*

Clinical and Radiological Aspects of Pneumoconiosis due to Hemp Powder. (Aspetti clinico-radiologici della pneumoconiosi da pulviscolo di canapa.) MAGRI, G. (1948). *Radiolog. med., Torino*, **34**, 668.

The radiological changes seen after some years' exposure to hemp may be slight, and of the 40 patients examined few had worked for less than 10 and many for as long as 50 or 60 years. The changes observed have been divided into three stages. In the first there is a more definite marking of the lung shadows with hilar hypertrophy and some pleural or interlobar thickening. In the second stage nodular, miliary, and sub-miliary shadows may appear, but neither in this nor in the first stage are symptoms invariably present. In the third stage the nodular shadows may become confluent with tumour-like appearance of considerable density. Zones of emphysema and atelectasis develop at the same time; there may be bronchiectasis and possibly cavitation with associated tuberculosis. Cough, dyspnœa, and recurrent bronchitis vary with the severity of the condition. Emphysema was noted in many of the patients, but few of these were young men. Hemp dust is essentially irritative and has no marked tendency to cause sclerosis of the lungs or to incapacitate from work. It was noted that some of the worst cases were in younger men who had only worked for a short time, and the authors suggest that the capacity of the nasal mucosa to fix dust is a possible explanation of these discrepancies. They also postulate a variation in susceptibility to the effects of the dust. The stance used in working may affect the amount of penetration. Many of the workers

stooped forward for the greater part of the day, whereas others did not. There was no evidence to show that hemp dust favoured the development of tuberculosis. In Italy hemp dust must be considered a serious occupational risk, especially in the province of Emilia, where hemp is widely cultivated. Some of the bronchitic manifestations appear to have an allergic character

G. C. Pether.

Pneumonoconiosis from Synthetic Abrasive Materials. SMITH, A. R., and PERINA, A. E. (1948). *Occup. Med.*, **5**, 396.

Radiographs from metal-grinders who use grindstone made of carborundum (silicon carbide) have shown nodular mottling. In order to exclude iron dust as the cause of this shadowing the authors studied a group of workers who ground alundum (an aluminium oxide) and carborundum to prepare an abrasive. Of 53 workers *x*-rayed, 7 showed nodular fibrosis; of these, 4 had been exposed to other significant dusts or had tuberculosis, and the other 3 were unexplained. It is suggested that silicon carbide, under the action of the alkaline tissue fluids, may release free silica. *L. W. Hale.*

The Heart in the Pneumoconiosis of Coalminers. THOMAS, A. J. (1948). *Brit. Heart J.*, **10**, 282.

A study was made of 96 cases of coalminers' pneumoconiosis. The disease remains for a long time in the "pulmonary phase" with dyspnœa, fatigue, cough, and pain in the chest. Later the "cardiac phase" supervenes, with increased breathlessness, œdema of the lower extremities, and upper abdominal discomfort. The picture of pulmonary heart failure with a full pulse and warm hands often gave way to less distinctive signs as the failure advanced. Right heart failure was present in 11 cases, of which 9 were fatal.

Radiologically, the heart is vertical and the outflow tract enlarged with enlargement of the pulmonary artery. The electrocardiogram showed a high P wave in lead II; chest leads showed a pattern of right ventricular hypertrophy in 7 cases. Sometimes a predominant S wave pattern was found in leads from the right chest, with a normal R wave; in these cases there was clinical and post-mortem evidence of right heart strain. Rotation and distortion of the heart may sometimes mask the more characteristic patterns of right ventricular hypertrophy. *J. McMichael.*

Tissue Responses to Physical Forces. I. The Pathogenesis of Silicosis. A Preliminary Report. EVANS, S. M. (1948). *J. industr. Hyg.*, **30**, 353.

No satisfactory explanation has been found for the difference in the responses of the tissues to "fibrosive" materials, such as silica, and to "benign" substances, such as carborundum and hæmatite. It seems that substances with the highest piezoelectric characteristics—that is, the appearance of electric charges upon the surface of certain crystals when they are subjected to outside mechanical stress—cause the greatest fibrotic responses in the tissues. In order to test this conclusion, wulfenite (lead molybdate) was studied because of its piezoelectric properties, its hardness in comparison with quartz, and its extreme insolubility. The wulfenite was ground in a ball mill until 50% passed through a 300 mesh screen; a dose of 50 mg. of it, suspended in distilled water, was injected into the peritoneal cavity of rats. The wulfenite was also injected into 15 other rats, which were then placed in a concentrated electromagnetic field of 1,200 megacycle frequency for periods totalling 33 to 231 hours. It was expected that in these last 15 rats the rate of tissue reaction to the wulfenite particles would be accelerated owing to their intermittent distortion by the electromagnetic field. As a control experiment, rats were injected with "benign" powdered mica, and some of them were also subjected to the influence of the electromagnetic field. The experiments showed that the wulfenite stimulated tissue responses beyond the usual foreign-body reaction as observed in the controls, and that the electromagnetic field greatly enhanced the speed and degree of fibrotic response in the animals. On the other hand, the control animals and normal animals which had not received injections were unaffected by the electromagnetic field.

H. M. Vernon.

Aluminium Therapy in Advanced Silicosis. BERRY, J. W. (1948). *Amer. Rev. Tuberc.*, **57**, 557.

This report concerns 26 men who received the treatment and 9 controls. All were in an advanced stage of silicosis. None had active, proved tuberculosis; in every case negative results had been obtained by culture and by guinea-pig inoculation. Nevertheless, tubercle bacilli were found in the sputum of 2 of the controls later in the investigation. The average time since the last exposure to silica was over 3 years. Treatment consisted in inhalation of hydrated alumina—"XH-1010," a very fine stable white powder, which does not flocculate as does the powder of metallic aluminium. The hydrate, which is probably formed in the lung itself after inhalation of the metal, coats the silicon particle with an insoluble gelatinous envelope. A machine was devised to deliver a constant known quantity of the powder in a concentration of 1 mg. per cubic foot (28,317 c.cm.) of air. This was inhaled for 20 minutes a day, 5 days a week, with 4 weeks' rest after each 4 weeks of treatment, and this was planned to be continued for 1 year but suffered interruptions. The controls were dealt with in the same way, except that they inhaled only room air but through the same machine. No significant physical change took place in any patient. The author considered that in 15 treated cases the condition was unchanged and that 8 became worse, while the condition of 6 of the controls remained unchanged and of 3 became worse. According to the patients' own views, 22 who were treated were improved and 4 unchanged, while all the controls felt improvement. The author concludes that the results of the uncontrolled experiments hitherto reported cannot be accepted as conclusive. *M. A. Dobbin Crawford.*

The Reticular Tissue in the Silicotic Lung. (Il tessuto reticolare nel polmone silicotico.) CESARO, A. N., and PECCHIAI, L. (1948). *Med. d. Lavoro*, **39**, 216.

The authors examined the lungs in 3 cases of silicosis and 1 case of silico-tuberculosis. They found that in a recent silicotic nodule there is a reticular structure originating from the pre-existing "argyrophil" fibres, usually with lack of reinforcement of the reticulum at the periphery of the nodule. In the recent tuberculous nodule a reticular framework is produced by newly formed and pre-existing reticular fibres. At the periphery of the nodule there is reinforcement of the reticular structure. In the hyalinized silicotic nodule there is no reticular framework; at the periphery of the nodule there is a structure of collagenous lamellæ. In the tuberculous and in the silico-tuberculous nodule there

is no reticular structure in the necrotic part of the nodule itself, but there is a considerable mesh of argentophilic fibres around the nodule. When the silicotuberculous nodules become confluent they are surrounded by numerous reticular fibres, which do not show signs of metaplasia into collagen. The present view is that one of the most vigorous means of tissue defence against damaging agents is represented by the appearance of collagenous tissue ; it is possible that in these cases the defensive capacity of the organism is diminished. In the lung alveoli which lie between the sclerotic areas and are not functioning the reticular tissue shows hyperplasia and hypertrophy. *E. Forrai.*

Silicosis of the Mediastinal Lymph Nodes and its Complications. (Über die Silicosis der mediastinalen Lymphknoten und ihre Komplikationen.) LEICHER, F. (1948). *Virchows Arch.*, **315**, 341.

Of 4,000 consecutive necropsies, 2,018 were on men over 30 years of age. Of these, 277 (13·7%) revealed silicotic changes ; 21 (7·6%) suffered from isolated lymph-node silicosis, 125 (45·1%) from pulmonary silicosis (first degree), 47 (16·9%) from pulmonary silicosis (second degree), and 84 (30·3%) from pulmonary silicosis (third degree). Of 99 deaths caused by silicosis 50 were due to silico-tuberculosis, 30 to severe pulmonary silicosis, and 19 to lymph-node silicosis with complications. Silicotic scarring of the mediastinal lymph nodes nearly always precedes the lung changes due to dust inhalation and appears to be a necessary factor for the occurrence of severe pulmonary silicosis.

By the formation of adhesions to the œsophagus and shrinkage of the silicotic lymph nodes œsophageal traction diverticula and even fistulous perforations developed in 51 cases. Traction diverticula resulting from tuberculous lesions or anthracosis were observed 21 times. Oesophageal traction diverticula of silicotic origin occur above and below the tracheal bifurcation. Multiple diverticula have often been observed. Non-silicotic traction diverticula are usually single and localized to the region of the bifurcation of the trachea. The direction of perforation and the overwhelming participation of the right lung in the complications are conditioned by mediastinal topography.

Besides the frequent development of diverticula with secondary fistula formation and softening of the silicotic nodes, primary softening with broad perforation into neighbouring organs, especially the main bronchi, may occur. The perforations are followed by abscess formation or gangrenous pneumonia, bronchiectasis, empyema, pericarditis, or fatal hæmorrhage. Perforations are fatal within 4 weeks, rarely longer. *R. Schade.*

Neurological and Psychotic Symptoms in Silicosis. (In Russian.) SERAFIMOV, B. N. (1948). *Nevropat. Psikhiat.*, **17**, No. 2, 46.

Little notice has been taken of the pathological changes in the autonomic nervous system in silicosis. Among the neuro-psychic symptoms observed are loss of libido, loss of appetite, fatigue, loss of initiative, and difficulty of concentration. These symptoms were not accompanied by motor disturbances. Some patients complained of hearing voices and seeing everything coloured yellow. A few had psychosensory disturbances, but these could be controlled by intravenous injections of glucose with 5% ascorbic acid. Emotionally, patients easily lose control and weep readily. There are loss of reflexes, tremor of fingers and tongue, and increased muscular excitability.

The changes in the autonomic nervous system were investigated. The pupils were often dilated, but the reactions to light and on convergence were normal. The skin, especially of the extremities, varied in colour from pale blue to reddish-blue and was often dry and œdematous. There were no trophic changes, but there was loss of hair. The heart rate was altered and the tone of the sympathetic nervous system was raised. These changes are thought to be of diencephalic origin.

It must be remembered that the lungs are not only organs of respiration but also possess a complex system of sympathetic and parasympathetic innervation, connected through the medulla and hypothalamic region with higher centres. The lungs are equipped with enteroceptive reflexes, in the genesis of which an important part is played by the non-striated bronchial muscle. These bronchial reflexes are differently developed in various types of men. In the asthenic type, for instance, the bronchial reflexes are much weaker than in others. The authors consider that an analogy can be drawn between the development of tuberculosis and silicosis. Silica is a non-specific irritant causing a functional disturbance in the neuro-receptive apparatus of the lungs. This causes reaction in the whole autonomic nervous system. This in its turn reacts on the higher centres, whose vessels are sensitive to any irritant.
T. Guercken.

Toxicological Studies on Certain Commercial Silicones and Hydrolyzable Silane Intermediates. ROWE, V. K., SPENCER, H. C., and BASS, S. L. (1948). *J. industr. Hyg.*, **30**, 332.

" Silicones " are produced in a wide variety of physical forms, including fluids, resins, and rubber-like products. This paper deals with the action of some of the principal silicones on laboratory animals. It should be read in the original.

Squamous Cell Carcinoma occurring in Asbestosis of the Lung. CURETON, R. J. R. (1948). *Brit. J. Cancer*, **2**, 249.

Necropsy on a woman of 37 who between the ages of 15 and 22 had worked with asbestos disclosed a large left-sided bronchial carcinoma, predominantly squamous-celled, accompanied by asbestosis of both lungs.
R. A. Willis.

Pathology of Pulmonary Fibrosis, Including Chronic Pulmonary Sarcoidosis. MALLORY, T. B. (1948). *Radiology*, **51**, 468.

Four types of pulmonary fibrosis are described ; organized pneumonia, healed infarction, healed necrotizing pneumonitis, and interstitial fibrosis. In a series of 6,000 post-mortem examinations 59 cases of pulmonary fibrosis were found, exclusive of tuberculosis, silicosis, and lipid pneumonia. It is pointed out that the incidence of organized pneumonia in patients with chronic bronchial asthma is too high to be the result of coincidence, and that in radiation pneumonitis the picture is often complicated by scars of necrotising pneumonitis and healed neoplasia.

The author describes a progressive form of granulomatous pneumonitis healing by fibrosis, and presents evidence for considering this a form of localized pulmonary sarcoidosis. *A. Orley.*

The Metabolism of the Lungs from Normal Mice and from Mice Exposed to Phosgene. BOYLAND, E., and MCDONALD, F. F. (1948). *Biochem. J.*, **42**, 68.

The lungs of young adult mice are sufficiently small to allow of measurement of metabolism in the Warburg apparatus without mincing. Mean values of 7·3 for Qo_2 and 3·0 for Qo^N_2 were found. No great changes in the lung metabolism were observed in mice exposed to phosgene. It is therefore unlikely that phosgene œdema of the lungs is due to poisoning of enzymes concerned with glycolysis or respiration in the lungs.

G. R. Cameron.

The Retention of Aerosol Particles in the Human Respiratory Tract as a Function of Particle Radius. WILSON, I. B., and LAMER, V. K. (1948). *J. industr. Hyg.*, **30**, 265.

The problem investigated concerned the function played by particle size in the retention of aerosols in the lower respiratory tract. Homogeneous aerosols containing a trace of radioactive sodium (N^{24}) were inhaled at various breathing rates by 7 subjects (4 women and 3 men). The aerosols were of the same size, within narrow limits, and they consisted of equal volumes of water and glycerol, and a small amount of sodium chloride containing a trace of Na^{24}. After a 5 minute period of inhalation, a cylindrical Geiger–Muller counter, shielded with one inch (2·5 cm.) of lead except for a slit running the length of the tube, was placed horizontally against the chest wall in the axillary region. The β rays are absorbed in the body, but the γ rays penetrate, and they were measured for 4 minutes, starting half a minute after completion of the aerosol inhalation. The counter picked up radiation primarily from the peripheral portion of the lung near the chest wall, a region consisting mainly of fine air passages and alveoli. During the inhalation period the exhaled aerosol was collected on a filter, so that the overall retention could be determined. Also a 10-ml. sample of blood was collected from the arm 15 minutes after cessation of the inhalation and measured for radioactive sodium. The monodisperse aerosol was prepared by a modification of the method developed by LaMer and Sinclair, and particle size was measured by means of the higher order Tyndall spectra calibrated in terms of sedimentation rate.

In all tests breathing was by the mouth alone, and it appeared that when the retention was below 85% the logarithm of the retention varied linearly with the logarithm of the radius of the aerosol particles. Breathing rates of $5\frac{1}{2}$ to 20 cycles per minute were investigated, and the retention was found to decrease linearly with increasing breathing rate. The axillary counts showed that in all cases there existed a region of relatively high counts extending through particle sizes greater than 0·3 μ and less than 1·2 μ. The alveolar retention, which indicates the deposition in the smaller bronchi, bronchioles, and alveoli, depended markedly on the particle size, and on an average exhibited a 4-fold dependence within the range of 0·2 μ to 2·6 μ. It follows that if it is desired to introduce particles effectively into the alveoli, in general aerosols must be used which have a particle size less than 1·2 μ and greater than 0·3 μ. Other tests indicated that the maximum alveolar retention is of the order of 45% of the inhaled aerosol.

H. M. Vernon.

Pneumoconiosis due to Graphite Dust. GLOYNE, S. R., MARSHALL, G., and HOYLE, C. (1949). *Thorax*, **4**, 31. (To be abstracted later.)

SKIN DISEASES

Sensitization to Petrolatum in Ointment Bases. LEVIN, S. J., and MOSS, S. S. (1948). *Ann. Allergy*, **6**, 579.

Six cases of sensitivity to petrolatum or related substances are reported. In view of the widespread use of ointment bases containing petrolatum or related substances for the local treatment of allergic dermatoses, the possibility of sensitization to these substances is emphasized. The authors stress the value of usage tests as opposed to patch tests. *G. B. Mitchell-Heggs.*

Sunlight and Skin Cancer in Kenya. PIERS, F. (1948). *Brit. J. Derm. Syph.*, **60**, 319.

The present state of knowledge of the influence of prolonged exposure to sunlight as a cause of cutaneous cancer in man is discussed. "The wave-length limits are the same for carcinogenic and erythema-producing ultra-violet rays." These are the very short wavelengths between 2950 and 3200 A. The climatic conditions in Kenya as they affect the quantity of ultra-violet radiation, both visible and invisible, are described. The zenith angle of the sun is nearer 90° for a longer part of the day than in temperate climates; and much of the colony is high above sea level, as a result of which the air is freer from dust and moisture. "The cloudiness of the atmosphere is of less importance for the intensity of ultra-violet radiation." "A sky partially covered with white cumulus cloud also emits more radiation than a clear blue sky."

Sunburn is considered under 3 headings: (1) permanent sun-tan; (2) farmer's skin; sailor's skin (Unna); (3) chronic solar dermatitis (Norman Paul); xeroderma pigmentosa of adults (Unna). The variable tendency of these to develop into carcinoma is stressed. Statistical tables are given of the 51 cases in white people seen by the author since 1941, showing age and sex incidence, site of lesion, occupation, descent, and type of lesions. "Among the European residents in Kenya cutaneous cancer is second in frequency only to breast cancer." Farmer's skin and chronic solar dermatitis affect men and women in the proportion of about 4 to 1. The cutaneous cancers are chiefly of the basal-cell type and affect the face or exposed areas. Cutaneous cancers in non-Europeans chiefly affect the extremities and appear to originate from chronic ulceration, which is relatively common. "The conclusion seems to be justified that sunlight is the paramount factor in the causation of cutaneous carcinoma in Kenya." Some apprehension is expressed at the growing habit among the younger generation of Kenya of exposing themselves to the sun "with a truly alarming recklessness."

J. E. M. Wigley.

Occupational Skin Lesions due to Pitch and Tar. ROSS, P. (1948). *Brit. med. J.*, **2**, 369.

Workmen employed in processes using tar and pitch are subject to certain skin hazards: (1) Tar burns. (2) Simultaneous exposure to tar or pitch dust and sunlight or wind may provoke an erythema resembling sunburn and known as the "smarts." The chemicals involved are thiazine, thiazone, acridine, and other azines. (3) Allergic eczematous dermatitis. This is rare and not important. (4) Folliculitis and acne. (5) Melanosis, either as a deep tanning of the exposed parts or a more chronic pigmentation accompanying other changes produced by long exposure, namely keratosis and poikiloderma. (6) "Shagreen" skin, also produced by long exposure and characterized by keratosis, pigmentation,

telangiectasis, and alteration of the texture of the skin. (7) Neoplastic changes. These consist of keratoses, papillomata, and epitheliomata. The last is the most important hazard. The commonest lesion is the " pitch wart." There is a variable latent period between the initial contact with tar or pitch dust or both and the appearance of the growth, in the author's group of cases from 18 months to 34 years. The development of such lesions may be preceded by " shagreen skin " for years. The sites of election are the face, dorsum of hands, nape of the neck, ears, and scrotum. The lesions are of relatively low malignancy. The carcinogenic agent in tar and pitch is 3,4-benzpyrene. Gasworks tar, distilled at a high temperature, contains more of this substance than blast furnace tar or that produced by low-temperature carbonization. Wood tars are relatively harmless.

Tables are presented which show an increase in the number of cases of tar cancer notified since 1921. The apparent increase is attributed mostly to better diagnosis and notification, and the decrease in fatal cases to better and earlier treatment. Further tables illustrate the latent periods of incidence of the various skin changes met with, their relative frequency, and their sites. Prophylactic measures consist mainly of the provision of clean protective clothing and gloves, of the maintenance of a high standard of bodily cleanliness, and of the application of protective creams to the exposed parts.

G. B. Dowling.

ENVIRONMENT

Technical Aspects of the Los Angeles Smog Problem. JOHNSTONE, H. F. (1948). *J. industr. Hyg.*, **30,** 358.

Publicity has been given to the increasing atmospheric pollution in the Los Angeles area of the U.S.A. Occasionally its concentration is so marked as to cause irritation of the eyes and throat. The pollution is due to a large extent to the topographical and meteorological features of the Los Angeles basin. The prevailing winds in the day-time carry the dust and fumes from the industrial district into the residential sections, and the high and extensive mountain ranges to the north and east act as barriers to intercept air movement. At night the winds from the mountains carry the pollution back over the city and industrial area.

When the particles of an aerosol are large it is common to speak of the system as a fog, mist, or cloud. If the suspended material is the result of combustion or of destructive distillation it is called smoke. Fume, which may be either solid or liquid, is produced by volatilization, while dust is derived from natural and mechanical processes of disintegration. The blue haze which contributes to low visibility in the Los Angeles area is usually associated with aerosols of very small particle size, 0·3 to 0·5 μ in diameter. Solid particles serve as nuclei of hygroscopic particles and droplets in a natural fog, and range from 5 to 50 μ in diameter. During the war it was shown by tests on screening that the optimum particle size for greatest obscuration depends on the refractive index of the dispersed material and the wave length of the incident light. For instance, for oil smoke the maximum screening efficiency is obtained when the droplets have a diameter of 0·6 T, while for sulphur smoke, which has a higher index of refraction, the maximum obscuration is obtained when the particle diameter is 0·3 μ.

Various methods are suggested for removal of dust, fumes, and sulphur pollution products from atmosphere. They include cyclones, " gas scrubbers and washers, and electrostatic precipitators." *H. M. Vernon.*

Studies of the Control of Acute Respiratory Diseases among Naval Recruits. I. A Review of a Four-year Experience with Ultraviolet Irradiation and Dust Suppressive Measures, 1943 to 1947. WILLMON, T. L., HOLLAENDER, A., and LANGMUIR, A. D. (1948). *Amer. J. Hyg.*, **48,** 227.

Barracks and other common-rooms of a large training centre were submitted to ultra-violet irradiation in an attempt to control air-borne infection. It was concluded that ultra-violet irradiation had some effect on certain types of respiratory disease, but not enough for irradiation to be recommended for general use.

Studies of the Control of Acute Respiratory Diseases among Naval Recruits. II. Limitations of Ultraviolet Irradiation in Reducing Air-borne Bacteria in Barracks with Low Ceilings. JARRETT, E. T., ZELLE, M. R., and HOLLAENDER, A. (1948). *Amer. J. Hyg.*, **48,** 233.

The authors describe some problems encountered in an attempt to control the speed of infection by means of ultra-violet irradiation. Culture plates were exposed in irradiated and control barracks ; bacterial counts were generally lower in the former. Similar results were obtained when special search was made for α-streptococci. Evidence was found that some of the difference was due to the action of stray ultra-violet rays on the culture plates ; the authors concluded that their technique was unsatisfactory. *Scott Thomson.*

Studies of the Control of Acute Respiratory Diseases among Naval Recruits. III. The Epidemiological Pattern and the Effect of Ultraviolet Irradiation during the Winter of 1946–1947. LANGMUIR, A. D., JARRETT, E. T., and HOLLAENDER, A. (1948). *Amer. J. Hyg.*, **48,** 240.

The authors concluded that ultra-violet irradiation of the upper air alone was inadequate to control the spread of respiratory-tract infection.

New Data on Retention of Aerosols on Respiration. (In Russian.) LIVSHITS, I. I., LIKHINA, E. T., and ERENBURG, G. S. (1948). *Gigiena*, No. 10, 17.

Tests were made to study retention on respiration of aerosols containing condensation vapours (" smokes ") of zinc and cadmium oxides ; of aerosols of disintegration, containing quartz dust and aluminium powder, of which the first plays an important part in the ætiology of silicosis and the second is believed to prevent silicosis ; and of aerosols containing electrically charged particles. Zinc and cadmium oxide smokes were artificially produced in an electric furnace at 900°C., each ml. of the air containing 65,000 to 400,000 particles of cadmium oxide and 40,000 to 360,000 particles of zinc oxide. In 5 volunteers and 139 separate tests 45 to 90% of both types of smoke was usually retained on respiration. The manner of respiration, through the nose or through the mouth, did not influence the degree of retention. The average concentration of submicroscopical particles of quartz and aluminium powder was 45,000 to 60,000 per ml., and the retention was 46% (quartz) and 62% (aluminium). The total percentage retention of a mixture (90 parts of quartz and 10 parts of aluminium by weight) was slightly lower than the percentage of each of these substances retained when inhaled separately.

In general, the degree of retention was directly proportional to the concentration of dust particles in the inhaled air. Electrically charged particles of marshallite, aluminium powder, and kaolin were retained to a far greater degree than were the uncharged particles. This fact is of great importance in estimating health hazards in establishments where hard substances are worked (polished or turned), thus producing aerosols containing large numbers of particles bearing electric (friction) charges. *H. P. Fox.*

Hygienic Assessment in Penicillin Production Plant. (In Russian.) NEELOVA, N. S. (1948). *Gigiena*, **No.** 10, 29.

Investigations were conducted at two commercial plants producing large amounts of penicillin. Determination of spores of *Penicillium* in the air of all departments producing the drug were made by the coniometer, the average number being 1 to 5 spores per ml. The growth of mycelium was observed in 3 days and the appearance of pigment in 4 days after exposure of Petri dishes for 5 minutes at a height of 1·6 m. from the floor level. Washings from the walls, utensils, and hands of the workers produced large numbers of colonies on seeding. Material recovered from the throat and nose swabs on culture produced numerous colonies. Although the concentration of amyl acetate and chloroform vapours was 0·2 to 11·7 and 0·09 to 0·66 mg. per litre of air, no disease of the respiratory organs was found among the workers. Clinical examination revealed changes [unspecified] which to some extent may be ascribed to the action of amyl acetate and chloroform vapours.

H. P. Fox.

Hygienic Standards of Ventilation of Auditoria with Introduction of Air in the Lower Zones. (In Russian.) LETAVET, A. A., MALISHEVA, A. E., and KLYUGIN, S. A. (1948). *Gigiena*, No. 11, 19.

Tests were carried out on 120 volunteers in a climatic chamber fitted with a stand containing 9 chairs in 3 rows, the second and the third of which were each 33 cm. higher than the preceding one. The air from the air-conditioning installation was forced through the openings under the seat of the chair, through its back, or simultaneously through both types of opening. The most satisfactory results were obtained when the jet of conditioned air was simultaneously forced through the openings in the back and under the seat of the chair or directed to the person's face and chest when forced through the opening in the back of the chair. Men and women taking part in the tests complained of discomfort when the jet of conditioned air was forced through the opening under the chair and directed accurately against the feet and legs of the seated person. The air velocity should not exceed 0·1 ml. per second at 21° and 22° C. when 20 to 40 cu. m. of air are supplied per hour per person during winter and transitional periods. In the summer the velocity should not exceed 0·3 m. per second, and the temperature of the conditioned air should be 2° C. higher than in winter. *H. P. Fox.*

A Rapid Method for the Determination of Nitrogen Oxides in Air. FLAGG, J. F., and LOBENE, R. (1948). *J. industr. Hyg.*, **30,** 370.

The nitrogen oxides in air have hitherto been determined : (1) by conversion of the oxides to nitric acid by means of hydrogen peroxide and the estimation of the nitric acid by conventional means ; or (2) by absorbing the oxides in a suitable solution and determining the nitrous acid produced by means of the α-naphthylamine sulphanilic acid reagent, permanent colour standards being used for comparison. The new method here suggested is a quick and sensitive one, applicable to air-gas mixtures containing from 1 to 50 parts per million (p.p.m.) of nitrous oxide (NO_2).

To test the method, air samples containing NO_2 were drawn over small amounts of silica gel in glass tubes, the gas being thereby completely removed. The amount of gas adsorbed was estimated by means of diphenylamine dissolved in sulphuric acid. A blue colour is developed, the intensity of which is proportional to the NO_2 present. It was estimated by comparison with known standards ; these standards could be read only to 3 p.p.m., and they enabled the concentration of the gas to be read to ±5 p.p.m.—that is, with moderate accuracy.

H. M. Vernon.

Studies on the Use of DDT and Phenyl Cellosolve for Control of Pediculosis in Villages in Colombia. MONTOYA, J. A., and OSEJO, P. P. (1948). *Amer. J. Hyg.*, **47,** 247.

Louse-borne typhus is endemic in certain small highland communities in Colombia.

Two studies of a year's duration are described, and the authors conclude : "The results in Imues and Yacuanquer indicate that it is practicable and relatively inexpensive by periodic use of DDT and phenyl cellosolve to maintain the louse-infestation index of an entire community at a level sufficiently low to preclude typhus outbreaks and to reduce the incidence of the disease to a position of minor public health importance. They indicate that careful applications of these insecticides at intervals of 4 months to at least 98% of the population should maintain the louse-infestation rate at or below 5%."

Action of DDT on the Cockroach Blatta orientalis. (Sull'azione del DDT su *Blatta orientalis*.) RICCI, M. (1948). *Riv. Parassit.*, **9,** 143.

Tests have been carried out to determine the resistance of adults and larvæ of *Blatta orientalis* to DDT. Male adults were more sensitive to DDT than were females, and the larvæ were less sensitive than either ; but in each group there are individual differences in sensitivity to the toxic effect. Even among the larvæ the different degrees of sensitivity of the two sexes are maintained, so that this would appear to be a physiological character connected with sex. Those insects coming from places where DDT and other insecticides had been used seemed to have acquired some degree of resistance.

H. Harold Scott.

Studies of Resistance to DDT in Domestic Flies. (Contributo allo studio della resistenza all'azione del DDT nelle mosche domestiche.) BETTINI, S. (1948). *Riv. Parassit.*, **9,** 137.

The author tested the resistance of two strains of house flies to DDT, heat, cold, and methyl acetate ; the strains were a local one sensitive to the toxic effect of DDT and one from Arnaes (Sweden) relatively more resistant. In the latter the cuticle is thicker and contains more melanin than in the former, and the author wished to determine whether the increases in resistance was due to these morphological differences. He therefore injected 30 of the insects for each test with 5% DDT

in pure olive oil, using the same measured quantities, the site being the scutum and prescutum, the dose 50 μg. of the drug. The flies were 3 to 5 days old and laboratory bred and the results were observed for 4 hours after the injection, the number dying being noted, and thereafter during the next 20 hours. In the untreated controls the mortality was "almost nil," both in the sensitive and in the resistant groups. Of those injected with pure olive oil, 16 died within 24 hours in both groups. Of the sensitive group injected with oil and DDT, two died in 75 minutes, the rest in an average of 7 minutes. Of the resistant group, only one died within the 4-hour period, namely after 80 minutes, and 45% (13 to 14) died within the succeeding 20 hours. No difference as regards resistance was observed in male and female flies. The author concludes, that, apart from cuticular structure, thickness, and pigmentation, there is a real "physiological resistance" of the tissues and the lymph.

H. Harold Scott.

Some Results of Recent Work on the Newer Insecticides. KING, W. V. (1948). *Amer. J. trop. Med.*, **28**, 487.

A great number of new compounds were screened to test their value for: (1) the protection of the individual from biting insects; (2) the control of insects in living-quarters; (3) the area control of insects of medical importance; and (4) the chemical investigation of insecticides and their application. The present account is a summary of the more important recent accomplishments, among which he records: (*a*) five compounds for clothing treatment against *Trombicula*, which apparently were equally protective and more durable than the present standard benzyl benzoate; (*b*) several compounds which were effective as clothing treatments and long-lasting repellents to salt-marsh mosquitoes; (*c*) a new compound, parathion, which under laboratory conditions is more toxic than DDT to certain arthropods —it possesses the disadvantage of being "quite toxic to warm-blooded animals"; (*d*) in tests of cockroach dusts, several of the newer compounds were equal to lethane 384, and better than benzene hexachloride, in speed of knockdown; (*e*) the compound known as "TDE" proved promising when tested against *Simulium venestum* and *Prosimulium hirtipes*, being more toxic than DDT to their larvæ and, probably, less toxic to fish; (*f*) the pre-hatching or pre-flooding treatment was found to be an effective method of controlling flood-water species of *Aëdes*, DDT giving better results than other materials tested.

There are observations on the important phenomenon of the development of resistant strains of insects against DDT, which has recently attracted attention in Italy.

R. M. Gordon.

GENERAL

The Significance of Nuptiality with Respect to Interpretation of Sex Differences. JOHNSTONE, M. M., and HOSKER, M. E. (1948). *Brit. J. Soc. Med.*, **2**, 106.

The authors show that mortality, as between males and females, is higher among males of all ages from tuberculosis of bones and joints, pneumonia, bronchitis, and appendicitis, among adult males from peptic ulcer and suicide; among males under 15 from acute nephritis; among adult females from diseases of the thyroid and parathyroid, diabetes, and pernicious anæmia, and among females under 15 from whooping-cough. Mortality from respiratory tuberculosis shows an excess of female deaths in early adult life and an excess of male deaths in middle age and later life.

The daily regime and the morbidity of the single woman conform more to those of the male than do those of the married woman. The authors examine the possibility that differences which distinguish women as a whole are appreciably attributable to occupational status. They compare the mortality experience of single with that of married women. They find that at all ages married women suffer a higher mortality from cancer of the uterus; that from the age of about 45 they suffer a higher mortality from diabetes; that they have a rather lower mortality from bronchitis and pneumonia and a conspicuously lower mortality from tuberculosis, peptic ulcers, cancer of the breast, pernicious anæmia, and suicide. They quote Australian statistics which indicate that the ratio of deaths from cancer of the breast to deaths from cancer of the uterus amongst childless married women is more akin to that amongst married women than to the corresponding ratio amongst single women. The records of the Registrar-General for England and Wales show that mortality from cancer of the breast is highest in social class I, while that from cancer of the uterus is highest in class V, this being true for both married and single women.

Married women suffer a higher mortality than single women and men from only two diseases—diabetes and cancer of the uterus. With the exception of appendicitis, every disease which causes a higher mortality amongst men than amongst women also causes a higher mortality amongst single than amongst married women.

F. A. E. Crew.

Brucellosis in Industry. JORDAN, C. F. (1948). *Industr. Med.*, **17**, 176.

The incidence of *Brucella* infections in all the 48 States of the U.S.A. has been analysed. The number of reported cases for the years 1930–9 averaged 1·99 per 100,000 of population; between 1940 and 1946 this figure rose to 3·11. North Carolina, the only state attempting to eradicate brucellosis from dairy herds, had figures of 0·4 and 0·3 respectively. Vermont and Iowa had rates over five times the average. The infection was studied particularly in Iowa and here the rate more than doubled in 1947; in 25% of the reported cases there was no direct contact with farm animals, and the sex incidence was equal. In the remainder there had been contact, and 88% of this group were men; three-quarters of them were between 20 and 49 years old. Of 2,031 patients reported in 1940–7 from Iowa, 95% were either farm workers or meat packing house employees, but if the estimated population at risk in the various occupations is taken into account, the risk for veterinary surgeons is twice that for packing house employees, over 9 times that for farm hands, and 70 times that for town dwellers in general. Farm hands probably become infected through the skin when handling struggling animals. Active and latent *Brucella* infection has been found in earlier surveys to be present in 18·2% of meat packers. The criterion was an agglutination titre of 1 in 40 or higher. Pigs' blood had a positive titre of 1 in 80 or higher in 3% of the animals tested. In the packing houses most of the men affected with brucellosis were on the killing floors or engaged in meat trimming. *Br. abortus* accounted for 30% of the infections in Iowa between 1927 and 1947; 58% were due to *Br. suis*, and 11% to *Br. melitensis*. The latter seems to be caught from pigs, not goats. Blood cultures are recommended when industrial workers develop fevers; serological tests are next in importance, but skin tests may be confusing. The preventive measures suggested include

regular serological tests to detect early or subclinical cases, rubber gloves for those who handle viscera, care of minor injuries, cleansing of packing premises, and control of brucellosis in animals. *J. N. Agate.*

The Antibacterial Effects of G–5, G–11, and A–151, with Special Reference to their Use in the Production of a Germicidal Soap. PRICE, P. B., and BONNETT, A. (1948). *Surgery*, **24**, 542.

Tests were made to determine the efficiency of soaps containing 2% each of the diphenols G–5, G–11, and an ethylene thiourea and silver nitrate mixture called A–151. None of the antibacterial soaps was significantly more bactericidal or bacteriostatic than ordinary soap. There was little difference in efficacy between the three antibacterial soaps. Repeated washing with 2% G–11 soap exclusively for a fortnight materially reduced the bacterial population of the hands after the first day, and maintained it at a low level so long as the soap was used. As soon as its use was discontinued the bacterial population of the hands immediately rose to the pre-existing level. It was not enough to use G–11 soap for scrubbing in the operating theatre only; to be effective it had to be used every time and everywhere the surgeon washed.

These antibacterial soaps are toxic when injected intravenously in small amounts into dogs, and are therefore not recommended for cleansing open wounds. *Charles P. Nicholas.*

A Study of the Hands of Radiologists. BRAASCH, N. K., and NICKSON, M. J. (1948). *Radiology*, **51**, 719.

The authors examined the hands of 323 radiologists, including those practising radiodiagnosis and radiotherapy. Changes found in the epidermal ridge pattern varied from areas of slight flattening to extensive atrophy or proliferation; 48% of radiologists had some such abnormality. The authors quote 1·8% for normal controls, the figure given by Harvey. There appeared to be little difference as regards changes in ridge patterns between radiotherapists and radiodiagnosticians. Very few of the latter stated that they used lead gloves regularly. Study of the nail fold capilliaries showed that various degrees of distortion occurred with advancing years of work with *x* rays. Similar changes were found in elderly people not exposed to *x* rays, but the incidence of abnormality was higher among radiologists and changes became evident at an earlier age. No radiologist of the series who had been practising for more than 30 years was found to be free from abnormality of ridge pattern or nail fold. *A. M. Rackow.*

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

FIFTY-FOURTH MEETING

The Fifty-Fourth Meeting of the Association was held in London on Jan. 28 and 29, 1949. The Meeting was opened at the London School of Hygiene and Tropical Medicine by Prof. G. P. Crowden, who spoke on the physiological aspects of noise in industry. This was followed by a paper by Dr. D. R. Thompson, Medical Officer, De Havilland Aircraft Co., on Observations on noise on jet-engined test beds.

Dr. Thompson said that a jet engine was a very simple piece of mechanism. It consisted primarily of a tube open at both ends and in the centre of the tube a moving part resembling a cotton reel. The front end of the reel was provided with vanes and sucked in the air, compressed it and passed it backwards where it was mixed with paraffin vapour. This mixture was ignited and the resultant explosion caused a large increase in the volume of gas and this gas passed out through the rear end of the tube. The power of a jet engine was measured by thrust, and this thrust was the major actual motive power of the machine. A jet engine flung back a mass at speed and was thus flung forward.

In a jet engine there was only one moving part—the spindle on which the impellor and turbine disc were mounted revolving at 10,000 or more revolutions per minute, using 100 tons of air per hour at the speed of sound and ejecting gases at 1,000 miles per hour. It was, therefore, difficult to silence such an engine except by enclosing the engine itself and silencing both the intake end and the ejection end. This problem had been reasonably well controlled by building enclosed test beds of brickwork and using silencing methods. The intake end which received the 100 tons of air per hour was muffled by a series of splitters. Splitters were longitudinal partitions consisting of a metal base covered by rock wool and faced by perforated metal plating, which acted by absorbing sound waves. The air thus received entered a fairly large chamber—the air filter room. The noise recorded in the air filter room was 120 to 130 D.B. with a frequency peak of 2,000 to 5,000 c/s. This intensity or loudness and frequency was quite intolerable without protection. The splitters were so effective that it was possible to talk in front of them and hear nothing but a faint hiss. The engine itself was enclosed in a brick built cubicle on a concrete bed and the brick walls were covered with rock wool and perforated metal plates. The noise recorded here was 120 D.B. at 2,500 to 3,000 c/s. The crew were housed in an adjacent cubicle, sound-proofed in the same way; the noise measured about 80 D.B. at 100 to 300 c/s and ordinary conversation was quite possible. The outlet tube was passed through a hole into a 14-inch brick building with a slatted roof, where the gases could expand and escape through the openings in the roof.

Personnel were adequately protected from noise except when it might be necessary to do running adjustments to the engine in the engine cell. For this purpose individual protection was required in the form of ear-defenders, which were of two main varieties: those which were inserted into the ear, such as wax or wax and wool, plasticine, etc.; or metal and plastic cups

covering not only the meatus, but the mastoid process as well and closely fitting to the skull.

Dr. Thompson said that the sensation of noise was produced by the pressure in air of compressional waves set up by some vibrating body. When several noises arrived at the same point of equal intensity or loudness the combined noise was only slightly above that of any one component. Generally speaking, the effects of vibration could be grouped into : (*a*) those felt—coarse vibrations—low frequency ; (*b*) those heard—threshold of audibility, 20 D.B. and frequencies 30 to 20,000 c/s (threshold of pain—130 D.B.) ; and (*c*) those neither heard or felt—ultrasonic.

In regard to (*a*), this was a question of vibration which affected the peripheral proprioceptive mechanism and would cause physical and mental fatigue which was to some extent under control of the person himself. The body tissues reacted to compressional waves in the same way as auditory apparatus ; therefore it was assumed that tissues such as the eyeball, lungs, etc., responded to vibrations and might cause disturbances of sensation : this we were not yet in a position to verify.

In regard to (*b*) ; the human ear had a sensitivity range from about 30 c/s (a whisper) to 16,000 c/s in a young adult which lessened as the subject grew older, coming down to about 10,000 c/s at the age of 60. The B.B.C. " pips " were just under 1,000 c/s : speaking voice was about 400 c/s.

Prolonged exposure to noise of high intensity and frequency produced temporary and, if prolonged, permanent damage to the organ of Corti. Sections from mice and guinea-pigs exposed to 500 c/s at 150 D.B. showed degeneration of the basilar membrane and distortion of the hair cells. No results of post-mortem examinations had been possible or even practicable in man, but surveys had been done on Service personnel exposed to jet engine noise under Service conditions, and compared with similar men not so exposed. These men had been observed over a period of twelve months, and audiography, encephalography, and clinical reports had been compiled. The results showed that where there was a small loss in the higher frequencies at the beginning amongst both exposed men and controls—at the end it was found that the loss was distinctly greater among those exposed to noise. The loss amounted to 20 D.B. in the 4,096 band, whereas in the Controls the loss was much less and even stationary. This suggests that the natural loss of high frequency tones was more rapid in those exposed to noise if they were susceptible. This finding was much the same as in pilots of reciprocating engines. High frequency waves of low intensity were fairly easily screened by air, walls, and glass. Noise might reduce work efficiency up to 25 per cent., depending on intensity, frequency, and continuity. It was noticed that the low drone of engines and props—high intensity and low frequency—produced sleepiness.

Dr. Thompson went on to say that the psychological effects of noise were largely controlled by the emotional background and stability of the subject. It had been proved that men with a balanced outlook on life and work did not show psychological symptoms when performing a job in which they were interested. Clinical observations of test bed personnel and a careful examination of sick absence over seven years had not shown any evidence of abnormal absence or sickness, and the percentage of lost time was lower in each period than that of other sections of the factory.

Jet engines produced vibrations in the upper sonic range, plus vibrations in the ultra-sonic range, but to the best of our present knowledge the vast majority of vibrations occurred in the sonic range. We had so far no evidence to show that ultra-sonic frequencies of the intensities so far encountered in industry and aeronautical conditions were harmful to personnel or produced any symptoms.

On Jan. 29, the Meeting continued at St. Mary's Hospital, Paddington, when Mr. J. F. Simpson, Surgeon in Charge of the Ear, Nose, and Throat Department, spoke about the deafened workman.

Mr. Simpson said that the war had helped towards a better understanding of traumatic deafness, and the present industrial drive should give opportunities for applying this extended knowledge. It was important to detect and prevent occupational deafness. Vocational rehabilitation enabled the deaf workman to take his rightful place in industry.

Cases fell into three groups : (1) where deafness was present before entry into industry : (2) where it began, or at least was first noticed, during employment, although not caused by it ; and (3) where it directly resulted from the occupation.

The first group was composed mainly of young adults suffering from hardness of hearing usually as a result of suppurative otitis media in childhood. The group contained those who were severely or totally deafened as the result of congenital or meningeal disturbances, who would have been pupils at special schools and would have received vocational training. The second group contained chiefly older employees developing otosclerosis or nerve deafness, the latter sometimes associated with arteriosclerosis.

Some deafness in the last group was only indirectly occupational : for example deafness from industrial accidents causing a fractured skull ; rupture of the tympanic membrane by blast ; otitis media either resulting from repeated upper respiratory infections following exposure to cold or damp working conditions, or from sudden and extreme changes of temperature or poor ventilation. Allergic rhinitis might act similarly. Certain industrial poisons acted directly on the neural mechanism or on the blood vessels supplying the cochlea, and caused deafness. These included arsenic, lead, phosphorus, carbon monoxide, carbon bisulphide, mercury, and the aniline dyes.

Barotraumatic otitis caused by flying in non-pressurized aircraft or diving in non-rigid suits, was temporary, but repeated attacks and secondary infection might effect permanent damage. The sudden decompression of Caisson workers could result in permanent deafness from the embolic effect of nitrogen bubbles (on the cochlea).

The most important hearing hazard in industry was acoustic trauma, which resulted from either : (1) sudden intense or explosive noises causing immediate and often permanent deafness, or (2) continuous exposure to a high-level noise, though often below that causing pain, producing an insidious, progressive, and permanent deafness.

It had been shown by animal experiments that the injuring sound led to degeneration of the sensory hair cells of the cochlea together with secondary degeneration of the associated nerve cells. That part of the cochlea concerned with the hearing of high tones was the most susceptible, and it was here in the basal turn that the effects of continued exposure to loud noises were first apparent. Curiously enough drugs (salicylates and quinine) and poisons attacked this same part first. The tones for which hearing was first lost were higher than those employed in speech ; thus some damage

could be done before the sufferer was aware of any defect in hearing, although such a defect was detectable and measurable by modern methods of testing. The early detection of this high-tone loss, and the withdrawal of the subject from noisy surroundings, would prevent further deterioration. A ringing tinnitus was frequently an annoying accompaniment of deafness.

Harmful noise levels were found in: (1) the metal-working industry, especially chipping; (2) pneumatic tool employment; (3) spinning and weaving; (4) the bench testing of engines; (5) aviation; (6) locomotive and tractor driving; and (7) under service conditions when automatic weapons and artillery etc. were in use. Switchboard operators might suffer as a result of sudden loud cracklings and screams in the earphones. Protection in noisy occupations could be obtained by using moulded ear plugs or by reducing the noise generated and reflected by sound-proofing and screening, employing various types of foundations, and using rooms of a size appropriate to the amount of machinery.

If a reliable quantitative hearing record were made of all new employees in an industry, this would be a help if a claim were made later for loss of hearing through employment. There could be no doubt as to the desirability of regular periodic testing of those exposed to the hazard of acoustic trauma.

Older methods of measuring hearing by the spoken voice, tuning fork, watch tick, etc., were inaccurate. Today an accurate method of measuring hearing loss was provided by the pure-tone audiometer. Audiometry was not a lengthy procedure, but required uniformity in conditions and use. The shape of the graph or audiogram obtained was sometimes characteristic of certain types of deafness, but the audiometer had not replaced the routine diagnostic clinical examination, which must include the taking of a past and family history, otoscopy, examination of the Eustachian tubes, and the various qualitative tests carried out with tuning forks.

If deafness were discovered and its type and degree correctly diagnosed, there would be opportunity for the correct placing of the deafened individual as well as the chance of treatment.

People suffering from a simple conduction or obstructive type of deafness as results from otitis media and otosclerosis were very suitable for working in a loud noise. The middle-ear dysfunction acted as an ear plug damping the intensity of the noise and so protecting the inner ear from injury. These patients heard conversation in a noise better than those with normal hearing (paracusis). On the other hand those with an inner-ear or perceptive type of deafness would be rendered uncomfortable by the distortion of sounds and their deafness might be further increased by noise.

Individuals with normal hearing but with a predisposition towards noise deafness might be detected by tests designed to show any increased tendency to aural fatigue.

The essence of the auditory function was the understanding of speech. The loss of hearing in one ear only, even if total, was very little handicap except in recognizing the direction of a sound and in the bad result if the good ear became deafened.

It might be questioned whether pure tone audiometry could show just how well or how badly an individual could hear speech, or if he would be helped with a hearing aid. In the conduction or middle-ear type of deafness there was an approximately equal hearing loss at all the speech frequencies. In this type of case the audiogram gave a good indication of the hearing for speech and of the help to be expected from the hearing aid. In perceptive or inner-ear deafness the pure tone audiogram was not such a reliable guide. These cases did not have a loss which was equal at all frequencies; it was most marked in the high tones which were employed in forming the consonants. Thus if the same amplification were given to all frequencies, high or low, either by a hearing aid or by raising the voice, undue loudness would be sensed for the low vowel sounds while the high consonants would still be inaudible. Selective amplification of the higher frequencies was required. This high tone boost could, in fact, be provided by the modern electric aids.

Although those with nerve deafness could not hear high tones when faint, they frequently heard the really powerful high tones just as loudly as anyone else. The transition from hearing little or nothing to hearing very well was abnormally abrupt. This condition where faint or moderate sounds could not be heard while at the same time there was no loss in the sense of loudness for loud sounds was called recruitment. It explained why old people complained one moment that they could not hear the speaker and the next that he was shouting too loudly. It also explained why a hearing aid was harder to fit when the deafness was of the nerve type. It was therefore important that we should have some reliable gauge for the hearing of speech when considering the necessity of using a hearing aid. It has always to be remembered that aids could not do everything, they could not activate dead hair and nerve cells, nor would they help if amplification had to be pushed to the point of discomfort.

Under the National Health Service any choice of instrument had been largely done away with as there was only one Government electrical hearing aid, and any choice would be restricted to those who wished to buy commercially manufactured instruments privately. There were certain basic principles which an efficient electric aid had to fulfil. It had to be small, light, and durable, amplifying sound without unnecessarily impairing quality. In America aids were examined and accepted or rejected by the Council on Physical Medicine; as yet no such system existed here.

The National Institute of the Deaf did try to protect the hard-of-hearing public by insisting among other things upon a trial before purchase. At present the usual way of assessing whether an aid was satisfactory was to see if the patient obtained real benefit after a trial of about ten days. Though this allowed the patient to try out the instrument under various listening conditions, it was not a very satisfactory method as the patient had to find out everything for himself. Ideally the patient should be encouraged by a trained instructor and properly taught how to use the aid and how to take care of it. Whenever possible he should be taught to lip-read; the importance of this could not be over-emphasized.

Auditory rehabilitation had been enthusiastically taken up in America, especially in connexion with ex-service men. American naval and military auditory training centres had been established where groups of patients underwent an eight-week course. These institutions were perhaps over elaborate, and had large staffs which included otologists, psychologists, psychometritians, and instructors in auditory training, speech reading, and speech correction, not to mention social and recreational workers and vocational and educational councillors. To deal with young men relatively pliant and eager, and who did not have to give up working time, was a very different matter from training a middle-aged or older working man who was trying to support a

family. There was opportunity of improving the lot of the deafened workman in this country on less ambitious lines than those offered to the American veteran. There was no large-scale or national service for the rehabilitation of the deafened workman yet, but when such a service did come into being it should include means for gathering cases into groups, as group teaching was probably best.

In deciding what vocation was best suited to the individual it would be necessary to know something of his work capacity and tolerance, and whether he had become psychologically readjusted to his handicap. The industrial medical officer was in a unique position to act as the vocational councillor. He had intimate knowledge of the conditions inside the workshops and factories, and understanding of the medical aspects of the problem. There should always be a follow-up and supervision of the deafened worker.

Mr. Ian G. Robin then read a paper on hearing tests and hearing aids. He outlined the disadvantages of commonly-used tests of hearing and continued with an account of the advantages and disadvantages of pure-tone audiometry. He went on to describe the essential properties of " Medresco," the Government hearing aid, and of proprietary aids. The testing of hearing aids by individuals, together with certain psychological aspects, were described. Mr. Robin concluded by pointing out that a happy deaf person is an efficient worker, and then showed on the screen a representative selection of audiograms illustrating such conditions as high-tone loss from severe trauma, bilateral radical mastoid cavities, and otosclerosis before and after the fenestration operation.

A paper on " The Treatment of Chronic Suppurative Otitis Media " was read by Mr. J. L. Wakelin. Mr. Wakelin said that regular and frequent aural toilet was the essential factor in treatment, but the haphazard instillation of drops or insufflation of powder into a chronically diseased ear was useless and in some cases might even lead to an exacerbation of symptoms. In many cases the chronicity of an ear infection was due to constant re-infection from a focus in the nose, nasopharynx, or mouth. The patient with a clear and intermittent discharge was much more likely to respond to treatment than the patient who had the foul discharge often associated with cholesteatoma. Working in an atmosphere of irritating dust or fumes might lead to chronic nasal congestion, with subsequent obstruction of the eustachian tube and impairment of drainage from the middle ear. The extent and site of any perforation should be diagrammatically recorded ; central anterior and inferior perforations showed a good response to conservative treatment, whereas those of the posterio-superior part of the membrana tensa and those of the membrana flaccida had a bad prognosis and were usually associated with chronic suppurative lesions in the mastoid antrum and air cells and in the attic region. Apart from cases with polypi, granulation tissue, and cholesteatoma, the greater percentage of patients with C.S.O.M. would be found suitable for conservative treatment in a factory clinic. Mr. Wakelin then went on to give an account of the detailed procedures necessary in carrying out an aural toilet.

The fourth paper in the symposium was given by Mr. D. V. Gideon, who spoke on " Acute Otitis Media." Mr. Gideon emphasized the importance of careful treatment of the acute ear and pointed out that it was only through the failure of the treatment of the acute condition that the chronic one was allowed to exist and persist. He went on to give an account of the treatment of acute otitis media, mentioning the points for and against the use of penicillin and sulpha-drugs. Finally, Mr. Gideon stressed the criteria of cure of acute otitis media, which were a healed tympanic membrane and normal hearing.

A demonstration of audiometers and hearing aids was given by Mr. Simpson, and the President thanked the speakers for their interesting papers.

SCOTTISH GROUP

Chairman : Dr. D. Gordon Robertson,
I.C.I. (Explosives Division), Stevenston,
Ayrshire.

Hon. Secretary : Dr. William Hunter,
William Collins Sons and Co., Ltd., Glasgow.

On Jan. 12, 1949, the Scottish Group visited Stobhill Hospital where Dr. A. S. Rogen and his assistants gave a review of cardiac disease with special reference to all groups of pathological types seen in industry. His remarks were illustrated by cases, case records, and radiographs.

On Feb. 16, 1949, the Scottish Group visited Kilmarnock, where a tour of Messrs. Blackwood Morton's carpet factory had been arranged. After a tour of the works a short discussion took place on the rehabilitation of the disabled person in the carpet industry.

BIRMINGHAM AND DISTRICT GROUP

Chairman : Dr. W. Jeaffreson Lloyd,
Messrs. Guest, Keen, and Nettlefolds Ltd.

Hon. Secretary : Dr. J. G. Billington,
General Electric Co. Ltd., Witton.

On Feb. 15, 1949, at the Birmingham Accident Hospital, twenty members of the Group together with some Works Engineers and Designers, heard Mr. W. E. Awde, Industrial Officer of the Council of Industrial Design, speak on the aims and activities of the Council. The Council was set up in December 1944, by the President of the Board of Trade. It is financed by the Government, and the annual report on its activities is made to Parliament. The purpose of the Council is to promote by all practicable means the improvement of design in the products of British industry. The word design is taken to cover the many processes in the planning of goods for hand production by machine and to include structure, texture, form, and decoration. Good design is taken as meaning both practical convenience and beauty.

The industrial division offers manufacturers, designers, and interested bodies a general advisory service for the promotion of improved industrial design. A list of designers, each of whom has been interviewed and his work seen, is kept and is continually enlarged. Refresher courses for designers in industry are arranged. This Division welcomes enquiries from management and industrial medical officers, in the design and adaptation of canteens, rest rooms, and works surgeries.

The education division seeks to teach the general public design appreciation. So schools, adult education institutes, and other such bodies are offered a wide variety of visual aids to achieve this purpose. The Council also publishes its own monthly magazine *Design*, and many pamphlets for the Stationery Office.

MERSEYSIDE GROUP

Chairman : Dr. E. Holland,
Mersey Docks Medical Service, Liverpool.

Hon. Secretary : Dr. J. V. Manning,
Pilkington Bros. Ltd., St. Helens, Lancs.

The first meeting of the recently established Merseyside Group was held on Jan. 26, at the Liverpool Dock Offices through the courtesy of the Mersey Docks and Harbour Board. Thirteen members were present. When the minutes had been approved, the officers of the previous Merseyside Sub-Group resigned, and the Chairman, Dr. Morris-Jones, indicated that he did not wish to stand for re-election. Dr. E. Holland was elected Chairman, Dr. F. A. Wilson re-elected Hon. Treasurer, Dr. J. V. Manning elected Hon. Secretary, and Dr. N. MacDonald representative on Council.

There was considerable discussion on the best way to help the work of the industrial nurses in the area, and on the proposal of Dr. MacDonald it was decided to hold a general meeting of the two professions in the near future with the object of discussing ways and means of "improving relations." As a result a combined meeting was held on March 3 with the State Registered Nurses engaged in industry on Merseyside. Eighty-four nurses attended the meeting and there was an interesting discussion on the ways in which the two professions could be of assistance to each other on Merseyside.

SOUTH WALES AND WEST OF ENGLAND GROUP

Chairman : Dr. J. S. Spickett,
Messrs. Richard Thomas, and Baldwins, Ltd.,
Monmouthshire.

Hon. Secretary : Dr. G. Stenlake Mundy,
The British Aeroplane Co. Ltd., Bristol.

The February, 1949, Meeting of the South Wales and West of England Branch took the form of a visit to a coal mine and miners rehabilitation centre. The excellent arrangements were made by the Regional Medical Officer of the National Coal Board, Dr. Jenkins.

From Cardiff the party proceeded to Bridgend and thence to Nantymoel colliery in the Ogmore valley. The Manager, Mr. Hackford, took considerable trouble so that no practical details of importance associated with underground working in this colliery should be missed. The party was impressed by a demonstration of a Welsh invention which consisted of drilling the coal face to a depth of about 6 feet and then inserting a piece of apparatus on the end of which was a sealing device to block the hole. When the hole had been sealed at a depth of several feet, water was passed through the apparatus under pressure. As its egress through the drilled hole was blocked, it had to force its way along the seams and might come out several feet away from the point of entrance. In addition to reducing the dust hazard, miners had found that the amount of coal hewn per day was also much increased. On their return to the surface the party had a practical demonstration of the efficacy of pit-head baths. After leaving the colliery, members proceeded via Bridgend to the Miners Rehabilitation Centre at Talygarn, where the Matron acted as guide.

YORKSHIRE GROUP

Chairman : Dr. S. A. Underwood,
Rowntree and Co. Ltd., The Cocoa Works, York.

Hon. Secretary : Dr. C. Cresdee,
I.C.I. (Dyestuffs Division), Dalton Works,
Huddersfield.

A meeting of the Yorkshire Group was held in Hull on March 12, 1949. Mr. Arthur Cargill gave an interesting address about the Hull fishing industry. It was about 1844 that a prime catch of soles was first landed in Hull. In the early days, fishing was done from smacks, but about fifty-five years ago these gave way to the more modern trawlers, that steamed to more distant seas and eventually as far as Iceland. At present there were in service about 148 ships. The cod liver oil industry was begun comparatively recently, and the ships were provided with rendering plants for the fresh liver from which the oil was extracted and brought direct to the cod liver oil factory in Hull. The fishermen of Hull were full of adventure and commonsense, and no fishing ground was too far away for them.

The medical service to the industry started in a small way in 1930, and Dr. Burns had built up from such small beginnings a service of which the industry was proud.

Mr. Cooper took members round the Hull Ice Company, whose refrigeration units made 1,000 tons of ice a day by the ammonia process, the ice being used almost entirely for the trawlers themselves. The next visit was to a trawler built in 1948, where the members were particularly interested in the modern berths, messrooms, engine rooms, and Radar equipment. Dr. Burns then took members to the surgery on the dock side, to show its modern layout, spaciousness, and equipment, which included an *x*-ray unit. A visit was also made to the cod liver oil processing and refining factory, where modern methods of manufacture of cod liver oil were demonstrated. Films were shown relating to the industry, including "Arctic Harvest."